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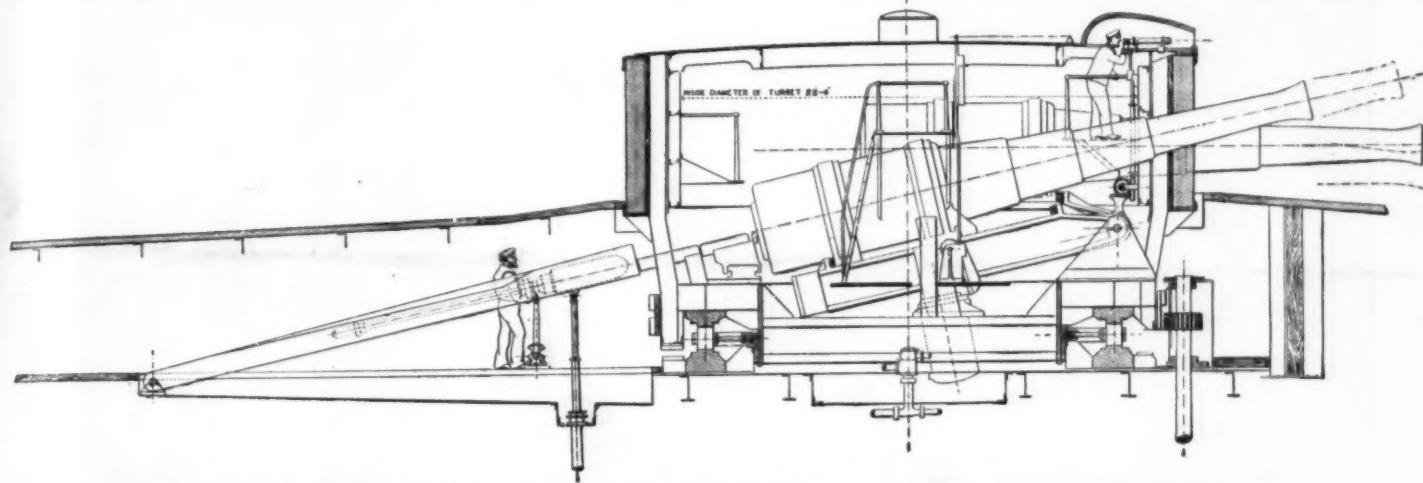
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H. M. S. EDINBURGH.

THE Edinburgh is a first-class twin-screw turret battleship, with armored citadel, but with ends unprotected except by a steel deck covering the magazines, engines, and other vitals.

The Edinburgh has a metacentric height of 9 ft.; the duration of rolling oscillations, in fighting condition, being nine seconds, the steadiness of the vessel having been very much increased by bilge keels. When the highest steam pressure was put on, it reached 64 $\frac{1}{4}$ lb. to the square inch. With this there was very little

roll, but the ship was not burned in the vicinity of the funnel casing. The armor of these vessels is disposed of as follows: Upon the sides of the citadel, which are 18 in. at the thickest part; upon the bulkheads, 16 in. and 13 in.; and upon the turrets, 16 and 14 in. There is also a teak backing from 10 in. to 22 in. The turrets are



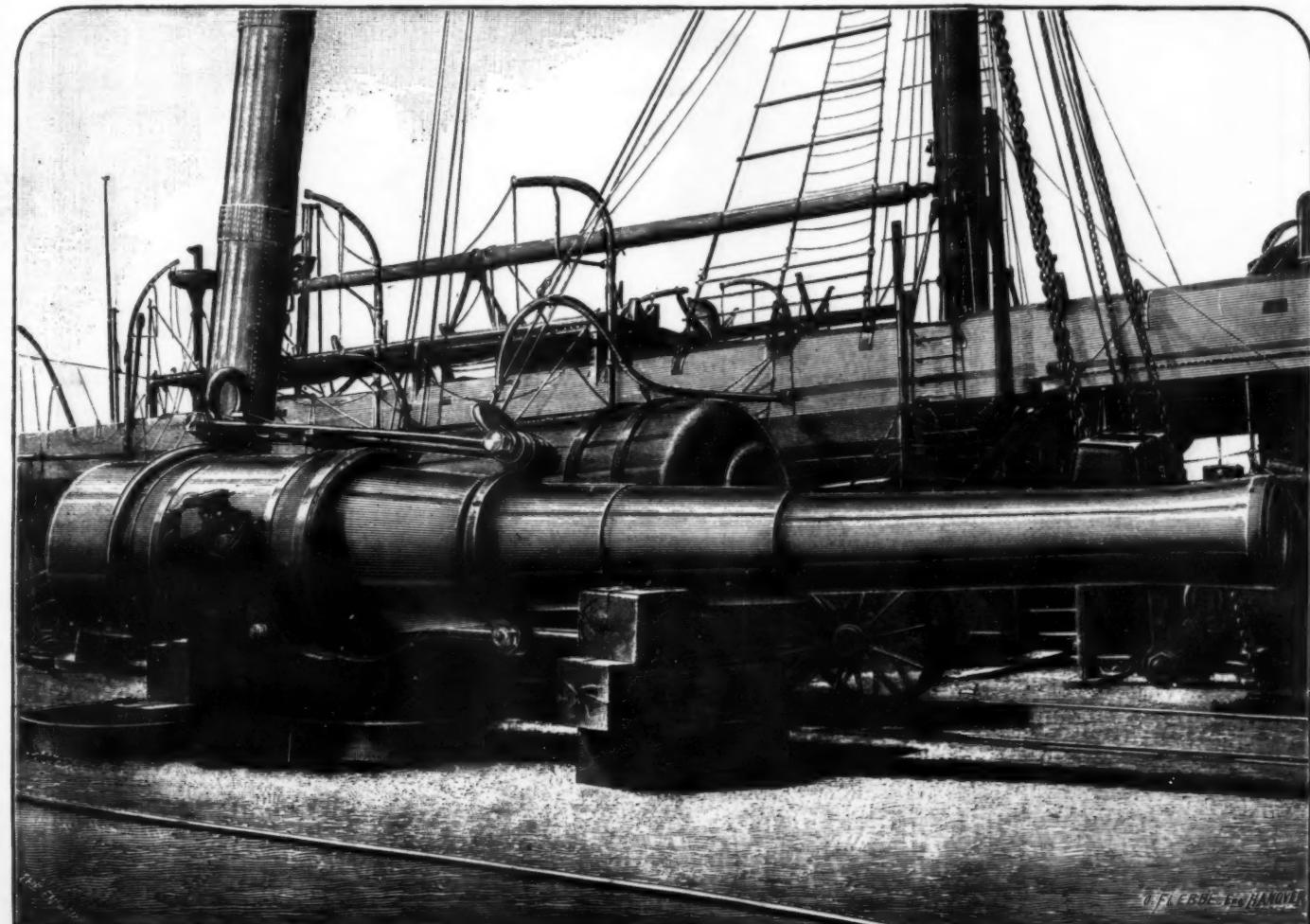
HYDRAULIC LOADING GEAR, FORTY-SEVEN TON GUNS, H. M. S. EDINBURGH.

This ship and the Colossus are precisely similar, the principal dimensions and other characteristics being as follows: Length, 325 ft.; beam, 68 ft.; extreme draught, 26 ft. 3 in.; displacement, 9,150 tons; both were completed in 1888; the engines of the Edinburgh turned out by Humphrys, those of the Colossus by Maudslay; indicated horse power, 7,500; speed, as tested on measured mile, 16 knots. The cost of the hull and machinery was about £645,000 in each case; the coal capacity 970 tons, sufficient for 6,200 miles at 10 knots.

vibration of the ship, but a considerable wave was thrown up in front of the bows. This is, however, the case with even the very lightest of our swift unarmored cruisers when driven at full speed, and in the more recent examples a water "run" is constructed diagonally across the forecastle deck, to conduct the combs of the waves over the sides when they break on board. The draught from all the furnaces being concentrated, in both of these vessels, through a single funnel, the heat generated at full speed is excessive, and it was found in the Edinburgh that the deck

placed diagonally, so as to present, simultaneously, a broadside or an end-on fire. The upper works generally, and the upper batteries, are unprotected by armor plates. This is of course the serious blot in the construction of nearly all our modern battle ships, in view of the effects of high explosives, but it will be remedied in future, as the secondary batteries are to be plated with 3 in. armor.

The armament consists of four 12 in. 47 ton breech-loading rifled steel guns, five 6 in. breech-loading steel guns, and twenty-two quick-firing and machine guns;



FORTY-SEVEN TON GUN, H. M. S. EDINBURGH.



HER MAJESTY'S FIRST-CLASS BATTLE SHIP EDINBURGH.

also torpedo tubes. An engraving will be found on first page of one of the Edinburgh's guns lying on the wharf preparatory to shipment, and above it we give a section of the turret and gun mountings for two of the 12 in. guns, which will penetrate 21 in. of armor plate.

The turret revolves on a roller path laid on the main or citadel deck, and its base is, in consequence, protected by the armor surrounding the citadel. It is turned by a pair of hydraulic engines placed on the deck beneath, and geared to the turret by vertical shafts and toothed wheels engaging with a rack carried near the bottom of the mounting. A special device is used to avoid any lash of the toothed wheels. These engines are controlled by a spindle passing through the axis of the piping at the center of the turret. This spindle is worked by a train of gear from either of the sighting stations; but these and other minor fittings are omitted in the engraving to avoid unduly complicating it.

The guns are loaded from the long boxes shown in the figure; and these are hinged at their rear ends to a pivot attached to the battery deck. In their normal condition they lie flush with the deck, and therefore offer no obstruction to the passageway. They can be charged either from above or from below, as may best suit other arrangements in the ship, and after charging are hoisted by the hydraulic cylinder, shown under the front end, into line with the elevated guns, whenever it is desired to load them. Each box contains a hydraulic rammer, which can be used to push the charge into the gun, after it has been brought into position.

The Edinburgh and Colossus have both given great satisfaction as good sea boats and for comfort in heavy weather. They present a steady platform for service of their guns. Their apparent high freeboard gives them in the water a more seamanlike exterior than the Conqueror and Devastation classes, or even the recently constructed Victoria, to which such epithets as half boots and flat irons have been felicitously applied. The cabin accommodation on deck is moreover a consideration of no small importance. One essential point, too, must not be forgotten. The possibility of an end-on fire in both directions is a most valuable feature in the attributes attaching to these vessels. It is not present in the Victoria.—*The Engineer.*

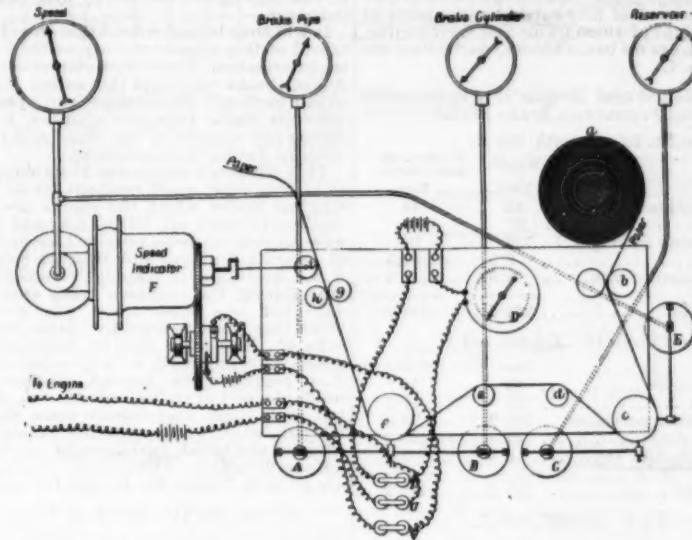
BRAKE TRIALS IN GERMANY.

In 1888 the Baden State Railways, who have their offices of administration and their works at Carlsruhe, began fitting up their passenger trains with the Westinghouse automatic brake, and in 1887 this work was practically finished, leaving but little to complete during the year 1888, while at the end of the latter they had 223 locomotives and 888 carriages completely equipped and 539 more carriages provided with pipes, so that all passenger and fast services on their line could be carried out with efficiently braked trains. All the South German lines, Bavaria, Wurtemberg, Main, Neckar, and several Swiss lines, including the St. Gotthard railway, soon followed suit, and either have completed or are now fitting up their rolling stock with the Westinghouse automatic brake. In the early part of 1888 some brake experiments were undertaken by the direction of the Baden State Railway near Heidelberg, and irrespective of other results the responsible authorities came to the conclusion that, for express service, satisfactory performance under all conditions can only be secured by all carriages being fitted with brakes, and this condition it has since been the desire

of the engineers to fulfill. As the pioneers of the introduction of automatic brakes in Germany they have watched with interest the development of this important question, and the results of the trials and demonstrations which took place in the spring of last year in America, with the new quick-acting Westinghouse brake, were eagerly studied by the technical superintendent, Mr. H. Bissinger, under whose special care this part of the equipment of trains on the Baden State Railways has been for some years past. Shortly afterward arrangements were made with the Westinghouse Company to supply the necessary fittings for one engine and fifty carriages, so as to enable the authorities of the Baden State Railways to repeat the Ameri-

the course of next month. The power of safely working trains sufficiently long to each convey a complete battery of artillery, or a complete battalion with its belongings, has a most material effect in organizing the mobilization of an army; but with the brakes ordinarily in use, trains of 45 to 50 carriages cannot be safely controlled if run at express speeds. It is in its power of effectively dealing with such trains that one very great advantage of the Westinghouse new quick-acting brake over other systems consists.

Turning now to the recent experiments at Carlsruhe, it will be remembered that the advantage of the arrangement of triple valve used with the new Westinghouse brake consists in more quickly releasing the



can trials and thus gain results by personal observation.

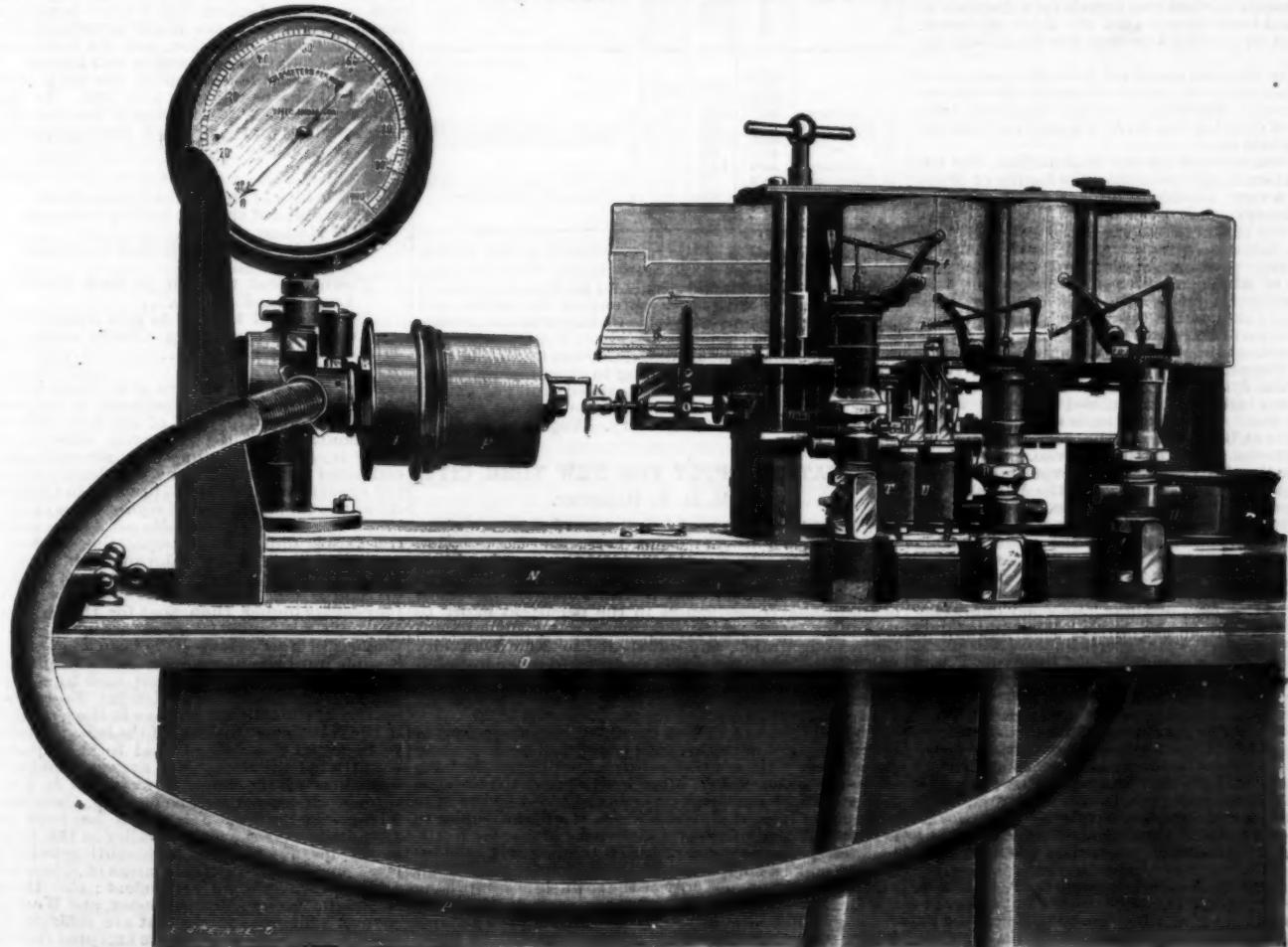
With the view of making the results of the trials on the Baden State Railways as perfect as possible and eliminating every possibility of error and accident, an elaborate and most complete programme was drawn up by Baurath Bissinger and his colleagues, and a distinguished party, consisting almost entirely of high railway officials from most of the German, Austrian, Italian, and Swiss railways, was invited. More than thirty accepted the invitation, and were present for the two days—March 19 and 20—on which the trials took place. It was remarkable, considering the evidently keen interest taken in these trials by the profession, that the scientific press was, with one exception—our own—not represented at all, but no doubt the results of the trials will ultimately be supplied by the direction of the Baden State Railways and will thus be generally available.

We may here point out that the question of efficiently controlling very long passenger trains run at a high speed has a very important military aspect, and this is a point which is at the present moment studied with great interest by the military authorities in Germany and also in France, where similar trials will be held in

pressure in the train pipe, thus applying the brake with greater precision and rapidity, even over a very long train, and that this more rapid action is obtained, first, by establishing communication between the train pipe and the brake cylinder, thus momentarily reducing the air pressure in the pipe, and, secondly, utilizing part of the air in the brake pipe, which, in the old brake, is exhausted.

That these recent improvements in the Westinghouse brake are capable of performing the necessary functions with much greater rapidity than has been previously possible, the experiments in America and at Carlsruhe have satisfactorily proved; and it may here only be mentioned that when the brake was applied to a standing train of fifty carriages, all fitted with the new quick-acting brake, and with a total length of over 1,500 ft., the last brake block was on its wheel within $1\frac{1}{4}$ seconds from the moment the driver's brake valve was operated.

The Carlsruhe experimental trains, of which there were three, consisted all of fully fitted carriages; they were, for the most part, four-wheeled third-class passenger carriages, each wheel braked, while the engine was one of the Baden State Railways' large four-



KAPTEYN'S AUTOMATIC TIME, PRESSURE, SPEED, AND DISTANCE RECORDER.

coupled passenger engines, with leading four-wheel bogie and a six-wheel tender; on the engine the four coupled wheels were provided with the usual brake.

Train No. 1 consisted of 18 carriages, and each of these carriages was fitted with the ordinary Westinghouse automatic brake as well as with the new quick-acting brake and the larger train pipes; in addition the quick-acting triple valves could be connected to the smaller train pipe; thus the following experiments could be made:

- a. Ordinary brake with small pipe.
- b. Quick-acting brake with small pipe.
- c. Quick-acting brake with large pipe.

Train No. 2 consisted of thirty carriages, similar to those in the previous train, but only fitted with quick-acting brake and large pipes.

Train No. 3 consisted of fifty carriages, the same as No. 2. Of the weight of these trains and their engine, as well as the pressure on brake blocks, particulars are given in Table No. I.

TABLE NO. I.—Weight and Length of Experimental Trains and Pressure on Brake Blocks.

Train No. 1a. Length, 535 ft.

	Weight. Tons.	Pressure on Brake Blocks. Tons.
1 Locomotive	45	18
1 Tender	27	13
16 Third-class carriages	153	91
1 Saloon	9.9	5.7
1 Experimental van	8.6	2.6
Total. 18 Carriages	249.5	130.3

Train Nos. 1b and 1c. Length, 540 ft.

	Tons.	Tons.
1 Locomotive	45	18
1 Tender	27	11.2
13 Third-class carriages	122.2	73.3
4 Goods vans	37.4	23.8
1 Experimental van	8.6	2.6
Total. 18 Carriages	240.2	128.9

Train No. 2. Length, 870 ft.

	Tons.	Tons.
1 Locomotive	45	18
1 Tender	27	11.2
23 Third-class carriages	216.2	129.7
6 Goods vans	56	34.7
1 Experimental van	8.6	2.6
Total. 30 Carriages	332.8	196.2

Train No. 3. Length, 1,545 ft.

	Tons.	Tons.
1 Locomotive	45	18
1 Tender	27	11.2
40 Third-class carriages	376	225.6
9 Goods vans	84.1	53.6
1 Experimental van	8.6	2.6
Total. 50 Carriages	540.7	311.0

The experiments were carried out on a level and straight piece of road on a branch line near Carlsruhe, where traffic is not extensive. For the purposes of observation, a flag was placed, marking the commencement of the trial division; in addition, a detonating cap was placed at this point and again 200 and 400 meters in advance. The speed of the train was measured between the last two signals on a distance of 200 meters, and immediately after the third explosion, at the moment of passing the flag, the brake was applied.

The distance run was measured from the position of this third signal up to the front wheel of the locomotive when at rest. The time in seconds was taken from the moment of opening the driver's brake valve to the moment of actual stop.

It will be remembered by our readers that, for the purpose of automatically recording the results of brake experiments, a very ingenious apparatus, devised by Mr. Albert Kapteyn, has been used. This apparatus, which, since our last notice, has been considerably perfected by its inventor, who has given it the name of automatic time, pressure, speed, and distance recorder, and of which we give an illustration, has, moreover, received some further additions from Baurath Bissinger; and in the trials at Carlsruhe it was placed in an experimental van in the rear of each train. Telephonic communication was established between this van and the engine, while in addition the driver's brake valve was fitted with an electric contact, so that its position was instantly transmitted to paper in the experimental van. The electric leads were fitted under the footboards at both sides of the carriages, and the necessary batteries placed in the rear van.

Of the recording instrument in the experimental van a clear conception will be gained from the diagram. In the apparatus an endless coil of paper, *a*, guided by vertical rollers, *b*, *c*, *d*, *e*, *f*, *g*, travels with a regular speed obtained from a strong clock work; the roller, *h*, being grooved and driven in close contact with the roller, *g*, pulls the paper uniformly at the desired speed. For the purposes of registering the various pressures, four indicators are attached; of these our wood engraving shows only three, the fourth having been added only recently for these particular experiments. Indicator *C* is in connection with Kapteyn's speed indicator, *F*, and shows the pressure in this, recording miles per hour. Indicator *E* shows the pressure in the reservoir. *A* in the brake cylinder, and *B* in the brake pipe.

It will thus be understood that while the commencement of the action of the brake is transmitted electrically, and is of course momentary, the conditions of pressure in the pipes are only measured after the action has traversed the whole length of the train, some 1,500 feet, and passed fifty triple valves. The two last named indicators, *A* and *B*, mark their indications vertically, one above the other, producing the lines 3 and 4, while three more indications in the same vertical line are produced by the electro-magnets, *T*, *U*, and *V*, but the lines produced by indicators *C* and *E* have to be shifted in a horizontal direction to their proper position to enable a direct reading to be obtained. This, however, will, of course, be done in the diagrams we hope to publish. Turning now to the electro-magnetic

contacts, it will be seen from the diagram that magnet *T* is in communication with a clock, *D*, which makes one contact every half-second; the pointer on this magnet therefore produces a saw tooth line showing half-seconds. Magnet *U* is a circuit with the driver's brake valve, and produces a mark in the line at the moment the valve is opened, while magnet *V*, not visible, is worked by an arrangement of gear wheels derived from the speed indicator, which makes contact once every ten meters run. In addition to these elaborate arrangements for observation, an apparatus designed by Mr. Hanshalter was erected in the experimental van which showed the average speed during every 19 seconds. This last instrument had its own independent driving shaft, but when the speed became uniform, its readings agreed excellently with the Kapteyn speed indicator.

It will thus be understood that from the diagrams obtained on this apparatus it is possible to read the following information: Time which elapses between opening of driver's brake valve and this action being transmitted to last carriage; the distance run; pressures of air in reservoir, brake pipe, and cylinder, before, after, and during any moment of the stop; and the speed at any moment during the experiment.

That with such appliances there should be no difficulty in obtaining exact readings for all the headings of columns under which the results are tabulated it is needless to point out, but we may add that so carefully were all contingencies provided for under the direction of Baurath Bissinger and Baurath Seiz, and so perfect is the operation of Kapteyn's recording instrument, that during the eighteen trials extending over two days not one observation was lost. Since some little time must necessarily elapse before all the results of these trials can be tabulated and the diagrams be reproduced, we will to-day only give the principal results of the various experiments under the heads of speed of trains, distance run, and time of stop, but even these may require some slight corrections later on, when we hope to have more to say on the effect of the latest development of the Westinghouse automatic brake. The general results just referred to are given in Tables No. II. and III. annexed:

TABLE NO. II.—Result of Trials, March 19.

Number of experiments.	Nature of stop.	Speed of train.	Distance run after application of brake.	Time from application of brake to stop.	Particulars of trains.
1	Ordinary.	44.7 miles per hour.	1,174 feet.	30 sec.	Train No. 1a, ordinary Westinghouse brake, small pipes, 18 carriages.
2	Emergency.	39.7	567	16	
3	"	43.5	650	17.4	
4	Ordinary.	43.5	1,292	31	Train No. 1b, quick acting brake, with small pipe, 18 carriages.
5	Emergency.	39.1	513	15.75	
6	"	44.7	613	17	
7	Ordinary.	44.1	904	25	Train No. 1c, quick acting brake, with large train pipe, 18 carriages.
8	Emergency.	38.5	506	15.6	
9	"	43.5	640	18.5	
10	"	48.5	794	21.25	

TABLE NO. III.—Result of Trials, March 20.

Number of experiments.	Nature of stop.	Speed of train.	Distance run after application of brake.	Time from application of brake to stop.	Particulars of trains.
11	Ordinary.	44.1 miles per hour.	1,516 feet.	34 sec.	Train No. 2, quick acting brake, large pipes, 30 carriages.
12	Emergency.	34.8	420	14.25	
13	"	40.4	504	16.7	
14	"	43.2	600	17.5	
15	Ordinary.	34.8	1,538	40.5	Train No. 3, quick acting brake, large pipes, 50 carriages.
16	Emergency.	29.6	302	12.5	
17	"	34.8	443	14.8	
18	"	36.0	402	15.5	

At the completion of the runs recorded in the tables, the train No. 1c was taken up an incline 7.5 miles long, with an average inclination of 1 in 80 and curves of 2,000 feet radius, with three stations on the incline, and the train was taken down this incline with an average speed of 31 miles. Of this descent it is difficult to give any particulars without diagrams, but it may be preliminarily stated that, according to observations taken by ourselves, the variations in speed did not exceed 9 per cent., and the control of the descent was, in other respects, quite satisfactory.—Engineering.

THE WATER SUPPLY FOR NEW YORK CITY.
By R. D. A. PARROTT.

WHETHER the rise and fall of water in storage reservoirs renders a locality unhealthy or not is a question that has been settled in the affirmative by experience in all parts of the world, and by litigation in the Croton drainage area. Still there is such a manifest disregard of traditional consequences in the persistent effort to make this latter region yield more water than its extent, configuration, and proximity to New York city will justify that it becomes essential to make a special investigation of the influences already developed by the prosecution of the work and to ascertain from existing data what results may be looked for in the future.

This discussion will bear chiefly on the movement of population in the Croton valley, and will tend to show that either "from evil or fear of evil" people have chosen to go elsewhere. In order to prove that migration or lack of immigration is due in any degree to the presence of impounding reservoirs, it will not suffice to accept the testimony of interested parties, or to depend on ocular evidence of thrift, but it will be necessary to make a comparison of the various enumerations of the population, not only of the townships comprising the Croton watershed, but of other parts of the country adjacent to the city. By an examination of this kind the average progress of a large area will be ascertained, and the backwardness of any particular section will be easily discernible.

It is assumed as a generally admitted fact that New York city exerts a positive influence of growth on the surrounding territory. To assert that no such expansive force exists, simply because no value has been ascribed to it, or because it cannot be estimated by any convenient unit of measurement, would be as difficult to maintain as that the city itself was at a standstill. While this developing influence may be fancied to radiate equally in all directions, its course is obviously controlled by the physical characteristics of the suburban country; so that the channels of most rapid settlement are, in the nature of things, the ones which have presented the greatest advantages and attractions. Under this view of an increasing community there is a dependence of the different divisions upon each other, and whatever action there is between them is reciprocal and of mutual benefit. The neighboring States of New Jersey and Connecticut share the stimulating influence of the overflow of population just as thoroughly as the State of New York. It is not at all material to know what degree of radiating power is exerted by the central source, but rather its partition, and since it acts freely, without discrimination as to political jurisdiction, this will be made apparent in the statistics.

The proposition is this, that the section of territory embracing the Croton basin should show like development and prosperity with any section similarly situated with regard to the city.

The great bulk of the watershed is beyond thirty-two and within fifty-seven miles of the Central Park reservoir; hence, if we take the latter as a center and describe two circles with these distances as radii, we will inclose a belt of country that may be said to correspond with the Croton basin in its relation to New York city.

The belt constructed on this method is twenty-five miles wide and includes parts of Suffolk, Westchester, Putnam, Dutchess, Rockland, and Orange counties, New York; Fairfield county, Connecticut; Passaic, Morris, Somerset, Middlesex, Monmouth, Sussex, Warren, Hunterdon, Mercer, and Ocean counties, New Jersey. The theoretical area of the belt is 7,350 square miles. The measured area of the land portion is 4,892 square miles, of which Connecticut has 530, New York 1,712, and New Jersey 2,650 square miles; the balance, 2,488 square miles, or thirty-four per cent. of the whole, is made up of the ocean, sound, and river.

The location of New York on the seashore confines the distribution of its overflow of people to a two-thirds portion of the encompassing area, and this circumstance creates a tendency to occupy lands farther off than would be the case if the city were inland, so that, while the radial distance of the belt from the nucleus places it beyond what is familiarly called suburban country, there is nevertheless abundant evidence that the pulsations are felt even to the exterior border.

The township has afforded a basis as to area and the census returns have supplied data as to population. The computation has covered one hundred and forty-two townships, a few of which required division, as they extended beyond the limit of the belt. The use of the statistics of so many small divisions diminishes the extent of possible error and gives to the conclusions drawn a more substantial claim for accuracy.

It may be argued that a calculation of the effects of the populating and developing force should be based on the natural resources of the suburban region or what might be styled its receptivity; but to entertain this view would require that all who sought rural property wanted it for one and the same purpose, whereas there is quite as much diversity in the seeking as there is in the land itself. While this selection of country is somewhat arbitrary, the belt is nevertheless of such variety and extent that it must be representative; besides, the examination is not being made of a wilderness awaiting immigration, but of a thickly settled region whose statistical record is well known.

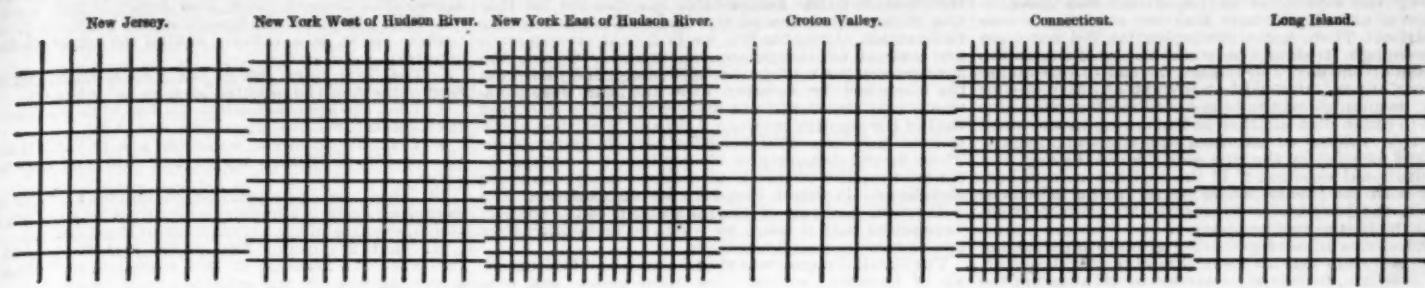
The following table exhibits the rank of certain divisions of the belt in the year 1880. To display the density more clearly, diagrams of the various divisions are also given in the order of their geographical position in the circle.

Divisions.	Density of population, 1880.
Townships of the belt in Connecticut...	180
Townships of the belt in New York east of Hudson river...	156.4
Townships of the belt in New York west of Hudson River...	116.8
Townships of the belt in New York, Long Island...	94.5
Townships of the belt in New Jersey...	80.7
Townships comprising Croton watershed...	66.4

From these it will be seen at a glance that the territory comprising the Croton basin is the most thinly populated of any division of the belt. The density of the country west of the Croton valley in New York State is one hundred and fifty-six and four-tenths as compared with sixty-six and four-tenths; on the other side in Connecticut the density is one hundred and eighty, a rise of one hundred and thirteen and seven-tenths per square mile. This is the simple difference in population between contiguous areas, one of which is devoted to impounding water and the others are not. The density of the New Jersey division is eighty and seven-tenths, or fourteen and four-tenths higher than that for the Croton. This is the more remarkable because many large portions of the belt in New Jersey have been comparatively inaccessible until recent years for lack of railroad communication, while others present such topographical features as to prevent their settlement. From a careful estimation of the railroad mileage in the Croton basin and in the New Jersey division of the belt, the ratio appears to be about one mile of road to five square miles of country in both cases. The average number of years of operation of the lines, however, is in favor of the former. It cannot well be claimed, therefore, that the advance in the New Jersey belt has been due to any advantage over the Croton valley in this respect. The townships of Ocean and Monmouth counties along the coast include considerable areas of tide marsh, which are not available for settlement; also the mountain regions in Passaic, Morris, Sussex, and Warren counties present numerous tracts that are difficult of improvement. Still none of these are excepted from the calculation.

If the country surrounding the city is in a measure

DIAGRAMS SHOWING THE DENSITY OF POPULATION OF THE DIVISIONS OF THE BELT.



dependent for its progress on a central field of activity, it would be most natural to expect that the evidences of such influence would diminish as the distance increased. To get the testimony of the statistics on this point, the section of the belt in New Jersey will alone be considered, for the reason that it constitutes more than half of the land area, and is, therefore, a fair criterion; besides, the more accurate survey of the townships of this State makes the subdivision practicable. By dividing the twenty-six hundred and fifty square miles of territory in five parallel belts, each five miles in width, and applying the enumeration of 1880 to them separately, it has been found that the first belt, or the one extending between the limits of thirty-two and thirty-seven miles from the Central Park reservoir, has a density of one hundred and forty-seven and eight-tenths per square mile, while the adjoining belts follow in their order with densities of eighty-five, sixty-two and seven-tenths, sixty-nine and three-tenths, fifty-three and three-tenths.

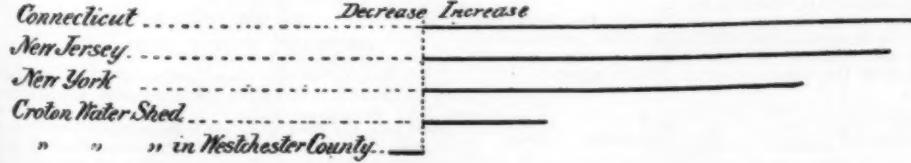
The difference in density of population between the exterior and interior minor belts is, therefore, *ninety-two and five-tenths*, showing a doubling of the inhabitants in a distance of twenty-five miles as the city is approached. There is unmistakable proof in these figures of two facts quite essential to the value of this discussion. First, that the city originates a positive growing force; second, that material gain in the country is due to absorption from the city, and not to local advantages.

A single enumeration of the population of the belt does not establish anything further than the state of things at that particular time, and, consequently, it cannot be inferred from the foregoing table whether the whole region was experiencing an increase or certain sections of it were running behind. The importance of any conclusion as to the status of the Croton district will depend on the relation of two or more enumerations which will indicate the direction and extent of movement of population. In the summary following, the townships of the three States are given in three groups to show more distinctly where the city has bestowed her surplus inhabitants during the decade 1870-80. A separate estimate is given for the townships comprising the Croton watershed:

Divisions of the Belt	Population.		Increase or Decrease.	
	1870.	1880.	Total.	Avera'e Annual
			Absol'e	p. c.
Connecticut . . .	80,477	95,272	14,705	18·4
New Jersey . . .	181,033	210,602	29,659	16·4
New York . . .	164,249	183,295	19,046	11·6
Croton basin . . .	26,308	27,406	1,098	4·2
			Absolute	p. c.
			1,363	12·20
			136·3	1·11

This table exhibits in a striking manner the rapidity of growth in certain portions of the belt. The degree of acceleration in each case is made plain by the following cut:

GRAPHIC COMPARISON OF AVERAGE ANNUAL PERCENTAGE OF GROWTH.



The Connecticut division shows a rate of growth *fifty-eight per cent.* higher than the New York division, and *three hundred and eighty-five per cent.* higher than the Croton watershed. The New Jersey division shows a rate of growth *forty-one per cent.* higher than the New York division, and *two hundred and ninety per cent.* higher than the Croton watershed.

Out of a total of seventy-one townships in the New Jersey belt, thirty-two show a decrease of population—a fact that might detract from the evidence of general increase if the falling-off is not actually due to local causes.

The area of three townships is 976 square miles, and the decrease in ten years was 3,664, or nearly *thirty-eight to the square mile*. Of this area forty-seven per cent. is in the counties of Sussex and Warren, which are situated on the northwestern slope of the Highland range, separated by a summit averaging from 900 to 1,500 feet elevation, from the more central and accessible portions of the belt.

An estimate of the decrease in these townships shows that the loss was *forty-seven to the square mile*, while that of the others, situated largely in the district of clay marls of the cretaceous formation comprised within the counties of Monmouth, Middlesex, Somerset, and Mercer, was only *twenty-one to the square mile*. If any conclusion is to be drawn from the first instance of retardation, it is that the region displays its inability to increase on purely local advantages, and, therefore, may be regarded as confirming the theory that the accelerated growth of the belt in gen-

ing the benefits of this overflow in proportion to the measured extent of each, the actual numerical gain, compared with the theoretical gain, will show in which direction the pressure from the city has found least resistance, or, in plainer words, which people have had the best eye to business.

It will be noticed from the following table that Connecticut has outwitted her rivals, New York and New Jersey, in the ratio of *two and one-half to one*, and the Croton townships in the ratio of *ten to one*.

Divisions of the Belt.	Area Per Cent. of Whole Belt.	Numerical Gain.	Theoretical Gain.	Actual Gain per Square Mile.	Theoretical Gain per Square Mile.	Increase or Decrease from Theoretical Gain per Square Mile.
New Jersey . . .	54	29,630	34,290	11·3	12·9	-1·7
New York . . .	35	19,046	22,210	11·1	12·9	-1·8
Connecticut . . .	11	14,705	6,985	27·9	12·9	+15·0
Croton townships . . .	8	1,098	5,334	2·6	12·9	-10·3

The growth of these different divisions of New York's suburban lands will not be so clearly distinguished by the foregoing tables as by the calculated

periods of doubling based on the increase during the decade 1870-80.

Division of the Belt.	Percentage Increase in Ten Years	Period of Doubling.
Connecticut . . .	18·4	40 years.
New Jersey . . .	16·4	"
New York . . .	11·6	64 "
Croton watershed . . .	4·2	176 "
Croton watershed, townships in Westchester County . . .	-1·0	"
New York City . . .	17	"

The backwardness of the Croton watershed appears quite incredible, and compels an inquiry as to what proportion this blighted area bears to the section of the belt between the Hudson River and the Connecticut line. Within these limits there are 616 square miles, so that the 300 square miles of the drainage area constitute *forty-eight per cent.* of the whole. To determine the density of population of the watershed, it has been necessary to make use of the areas of the townships comprising it (413 square miles), and consequently the results apply to *sixty-six per cent.* of the above section. It is very material to the interest of New York to know whether the region receiving a check in growth coincides with the watershed, or the first overlaps the second daily and hourly in accordance with the direction and force of the wind. Unless there is some conclusive evidence brought forward to refute the claim that, in consequence of the storage of water, the region has been put back many years, it would be in harmony with the existing state of things to say that the ridge line of the basin is not the boundary of the aquiferous area. The extent of the marginal country which has been thus estimated as if it formed part of the drainage area is seventy-four square miles.

Now, if it is held that this bordering tract is not affected by the work within the ridge line, then it must be classed with the contiguous land, acquiring a *rise in density of population in consequence, but at the same time diminishing the density of the basin in an equivalent degree*. Friends of the Croton may choose the alternative that may suit them best.

In order to approximate to what degree retardation has taken place throughout the whole basin, it may be assumed that, if the impounding reservoirs had never been built, this region would have developed equally with the balance of the land covered by this comparison. Classing it as no better than the average is detracting somewhat from the true relation it bore, for, according to the survey, the watershed includes thirty-one natural lakes, and these would of themselves constitute attractions not surpassed in the remainder of the belt. Besides, the susceptibility of the Croton valley to the stimulating expansion of the city was evinced thirty years ago, and its decline was coincident with the carrying forward of the water project. It matters very little what features of the project created this decline—whether it was that the inhabitant could not maintain his property or foresaw its gradual depreciation; whether he was enfeebled with malaria or only took the warning from his shuddering neighbor—for there is nothing conjectural in the general statement that the prosecution of the work has changed the character of the country. Opinions as to which feature has accomplished the greatest damage will be of little value and of no avail, since the scheme as a whole is at fault.

The average density of population for the entire belt is about 100 to the square mile, at which rate the townships comprising the drainage basin would have contained 41,300 inhabitants in 1880, instead of 27,400.

The interest of the public in this matter is not to be tested by the numerical loss that the statistics may prove so much as by the accompanying loss in valuation.

The per capita assessed valuation of all the townships in the belt averages *five hundred and twenty-one dollars*, and the total assessed valuation of the Croton townships is \$15,452,715. Ascribing to the watershed, as before, the average population of the belt, and allowing to each inhabitant the above rate of valuation, the total assessed valuation would then be \$22,994,615, an increase of \$7,241,900. This is, theoretically, the minimum value of property that would have been subject to taxation if the valley had not been partially monopolized by the water scheme.

This depreciation of property has been legalized under the beneficent principle of eminent domain, the scepter of oligarchy. But the acquisition of territory under this right presupposes that the use of it shall not injuriously affect adjacent land, while in this instance an inconsiderable area obtained by condemnation has diminished the value of a wide tract to measurable extent. In deep oblivion of what the exercise of the right had already brought about, the statesman of 1881 flaunted the rusty missile with seeming originality. The legislation authorizing the construction of indefinite dams and aqueducts was practically an imitation of the measures of fifty years ago; the law was only a new grafting on an old stump. Why should not the infirmities of the old scheme be transmitted to the new?

Surely, if malaria can be transmitted by inoculation, the present scheme is entitled to it. All the data exhibiting the movement of population was common property, and should have had the statesman's consideration. Then, again, the legislation did not have scope enough. It should have contemplated the appropriation of the entire watershed instead of one square mile out of ten. Under what pretext of dire necessity can it be maintained that one *public* shall sacrifice nine units in order that another *public* may gain one unit? Has this species of cannibalistic eminent domain, brought forward by the ripe politician of the day, any constitutional sanction? If the legislation is in harmony with the theory, where comes in the increment of gain, the inseparable adjunct to it? Which exemplifies the best economic policy of the State: to permit the 360 square miles of gathering ground to partake of the acceleration due to natural laws of development, and, in course, benefit by revenue, or to abandon the area to the retardation due to experimental legislation, sanitation, and engineering by which to enhance the prosperity of sister States?

The backward condition of the southern half of the Croton valley, as demonstrated by these comparisons, has probably been suspected, if not actually known, by a large number of people. In exactly the same way a large number of people know that there are one hundred and fifty million dollars' worth of property in the dry goods district of the city upon which there is no insurance, for the reason that the water supply is not deemed adequate for extinguishing fires.

In opposition to the truth of these views there is the comforting assurance that the present scheme has the endorsement of the best engineering talent of the day; in other words, it is the professional opinion that the remedy for an evil is to increase the exciting cause—that the true way to restore the backsliding section of the Croton valley to its normal condition is to impound more water there; that to make good the deficiency in volume and pressure, it is only necessary to ignore the fact that increase of distributing pipes attending the growth of the city diminishes the head, and then proceed to duplicate the gravity system of fifty years ago!

Ascertainment of the fact that periodic submergence of lake borders prejudices the occupation of adjacent land in the Croton valley, as well as elsewhere, makes it more manifestly important to obtain in the future a supply that does not involve the development of a district that may either receive its stimulus from the city or have resources which give it an independent and individual character. The experience of the past would not, for instance, justify the adoption of a plan for securing water by storage within the limits of the belt herein discussed.

Such a system would inevitably be attended by a thinning out of the population and depreciation of values in the region selected; the damage to be expected would correspond to the state of development already reached. In connection with a study of the meteorology of the Croton basin, the writer drew attention some time ago to the availability of the Catskill region for the immediate and future wants of the city. (SCIENTIFIC AMERICAN SUPPLEMENT, No. 557.)

That the supply is ample and susceptible of being delivered under sufficient pressure to relieve the people of the expense of pumping is apparent without much investigation. But the suitability of the plan would be somewhat disparaged by the Croton experience if there existed points of similarity between the two that foreshadowed a sacrifice of property or an unwholesome supply. A comparison of the settlement of the two regions brings into prominence the more favorable features of the Catskills. The three watercourses which would contribute to this supply are in the counties of Ulster, Greene, and Delaware, draining an area of 390 square miles. The mean elevation of the watersheds is 2,000 feet, and the distance from the terminal dam on Esopus creek to New York, about seventy miles. Since the townships which comprise these catchment basins have an area of 765 square miles, the calculations of density of population cover a margin of 235 square miles beyond the ridge line, but as these contiguous lands are similar in character to those within, it is thought that their separation, if possible, would not alter the general result.

SUMMARY OF POPULATION IN THE CATSKILL REGION.

Divisions.	Density per square mile.	
	Townships comprising watersheds.	Townships not affected by watersheds.
Ulster.....	82.7	107.0
Greene.....	27.4	51.0
Delaware.....	31.4	26.5
	80.5	61.5

It will be noticed from this table that the townships comprising the watercourses possess about half as many people per square mile as the balance of the counties, while in the case of Ulster County, by itself, the ratio is less than one to three. Such a marked disparity between contiguous lands indicates exceptional progress in the one or comparative inaction in the other. By reference to the census returns the question seems to be solved in favor of the latter. In 1855 Olive township in Ulster County had 2,924 inhabitants; in 1890, 3,927. In 1855 the population of the townships affected by this project was 23,430; in 1890, 23,436. The rate of increase for the five years 1870-75 in Ulster County was *four and eight-tenths*, in Greene *two and four-tenths*, in Delaware *minus two and four-tenths*, in the State at large *seven and two-tenths*. During the decade 1870-80 the absolute increase for the three counties was 2,375, or *one and a half per cent.*, while for the townships comprising the watersheds the decrease was 161, or *minus seven-tenths of one per cent.* It is thus seen that so far as immigration is concerned the counties show a small numerical gain, about two to every square mile, but that the townships affected by the drainage areas show a numerical loss. Accordingly, the region designated as a gathering ground does not appear to sympathize with the general progress of the State or to develop from local advantages.

The cause of this exceptional backwardness is the

elevated character of the region, which of course forbids settlement in the absence of natural resources. By reference to the census table showing the distribution of the population of the United States according to elevation above the sea, we find that *seventy-seven per cent.* of all the people are below 1,000 feet, and *ninety-seven per cent.* below 2,000 feet. The density of the whole country between 1,000 and 1,500 feet elevation is *eleven and one-tenth per square mile*, and that of the country between 2,000 and 3,000 feet elevation is *two and three-tenths per square mile*. These figures demonstrate clearly that the natural inclination of the people is to occupy valleys and low elevations. It would therefore be an exception to a well established rule if the inhabitants of the country were seized with a desire to reside on mountains from two to four thousand feet high.

The Catskill region was at one time a vast forest made up of hemlock, spruce, pine, hard maple, ash, oak, hickory, and basswood. The inducement offered by this virgin growth created early settlements along the streams. Large and successful tanneries utilized the water power and were only limited in their tenure by the supply of hemlock. Tanning was the leading industry twenty-five years ago. Owing to the gradual exhaustion of the hemlock, the business of gathering tan bark has dwindled to almost nothing; what remains of it is chiefly carried on in the adjacent county of Sullivan, and is not pertinent to this discussion. The hard woods are being fast consumed in the manufacture of chair stock, piano bars, roller blocks, clubs, bowls, trays, etc. The bass-wood is converted into excelsior. Barrel hoops are made from young hard wood saplings, headings from all kinds of hard and soft wood, while railroad ties and cord wood take their share in clearing the hills.

The forest commission, created by the legislature in 1885, give the substance of these facts and many others concerning this interesting section of the State in their report for 1886, for it includes a number of tracts under their direction. The State has acquired various parcels of land in these mountains by the tax sales of the comptroller. These sales have taken place almost exclusively since 1871. The extent of land thus purchased and under the control of the State is 46,318 acres; only 661 acres are in Sullivan county, so that *ninety-nine per cent.* of the State lands are in the counties affected by these watersheds. Of a total of 33,480 acres in Ulster and Greene counties, 13,772 acres are in the townships comprising the watersheds, and since the area of these latter is only one-third that of the counties, we may conclude that what is least desirable for business pursuits is identical with what is most suitable as a gathering ground for water. Under the direction of the forest commission, these lands will be hereafter protected from the inroads of the lumberman, and some evidences of the benefit of forest culture may be looked for. What is generally considered as the Catskill region is included in the counties of Ulster, Greene, Delaware, and Sullivan, having a combined area of 4,121 square miles. No part of Sullivan county is within the ridge line of the proposed drainage areas, which in fact form only a small part of the other three counties, say seventeen per cent. Upon first consideration of the devotion of this mountainous region to the demands of the city, it occurs to one that such a use would deprive the pleasure seeker of a choice part of his domain; but let us inquire as to this.

Estimates furnished by the various railroads entering the Catskills make a total of 120,000 people who travel to and from the different resorts during a season. Sullivan county receives the greater portion of these, but assuming that the resorts are equally distributed over the four counties, and allowing a stay of ten days for each person, there would be ten thousand people for four months, or thirty-five hundred people for a year. When these are apportioned equally to the four counties, the increase due to summer travel is seen to be equivalent to the permanent residence of *eighty-nine persons* on every *hundred square miles* of territory.

To exclude the boarder and the excursionist from 530 square miles out of the 4,121 would not be, accordingly, a public privation, nor would it be a charge upon the city to protect and care for the sanitation of such places as it seemed desirable to maintain. It is plain to see that under municipal control this fractional part of the Catskill mountains would eventually become a well organized pleasure ground, but still adapted to the requirements of water supply.

Bearing upon the two watersheds in the light of damage to be sustained by devoting them exclusively to the needs of the city, the following computations from data of the State census of 1875 are given:

	Area of Lands in Farms.	Cash value.	Ass'd Valuation.	Area.	Value.	
	Im-proved.	Unim-proved.	Per acre.	Per capita.	Square miles.	Dollars.
Croton.....	77%	23%	\$85	\$72	360	19,584,000
Catskill.....	43%	57%	18	168	530	6,105,600

There is abundant material in these statistical results as well as in the meteorological and physical data for speculation as to cost; that is, *how little* the supply would cost in distinction from the Croton creed of *how much*.

The conclusions which the details of this review appear to justify are briefly as follows:

1. That the density of population of the Croton basin is less than that of any division of country at an equal distance from New York.
2. That the density of suburban population decreases in proportion to the distance, and consequently New York is the source of immigration.
3. That during the decade 1870-80 population was sensibly retarded in the Croton valley and accelerated in the corresponding suburban regions.
4. That the section of the Croton basin within Westchester County has decreased in population since 1860, while the section of New Jersey similarly situated has increased in a higher ratio than any other section of the belt; in other words, the area of greatest retardation in the Croton valley corresponds to the area of greatest acceleration in the balance of the belt.

5. That the belt suburbs in Connecticut have benefited relatively by proximity to the city to a greater degree than those of either New Jersey or New York.

6. That in point of doubling of population, the Croton valley is a century behind the corresponding country.

7. That the ridge line of the Croton basin and the environment of the blighted area do not coincide.

8. That the apparent minimum loss in population in the Croton townships up to 1890 was 13,894.

9. That the apparent minimum loss in valuation in the Croton townships up to 1890 was one half the actual.

10. That the appropriation of limited areas in the gathering basin is a questionable, if not unconstitutional, exercise of the principle of eminent domain.

11. That the duplication of the system adopted in 1887 was not a necessity in 1881, inasmuch as there was more economical and suitable supply available.

The origin of any scheme for furnishing water to a city is found in a desire to supply a demand not yet developed, but foreshadowed. It is based on the expectation of growth, the principles of which have a normal character, but, so far as any requirement for water is concerned, the local and particular expansion is what occasions the demand and limits the scope. The spirit underlying all such projects is therefore change, and, since the present scheme overlooks entirely the marked change in the height of buildings in recent years—not to mention the increase of friction due to the laying of miles of distributing mains in new streets—how can it be said to conform to the spirit of the emergency?

When completed, the new aqueduct will increase the draught from the storage basins to their full capacity. What this capacity may afterward be brought to is uncertain, the estimates depending apparently on one's enthusiasm. Men who have been on the ground and seen the supply say that it will reach anywhere from 300 to 450 million gallons a day. These figures ostensibly form the basis upon which the city is now providing aqueducts to convey 350 million gallons a day, *with or without* the big dam at Quaker Bridge. It is pertinent to recall just here that the meteorological record of the Croton Aqueduct Department discloses the fact that 270 million gallons is the maximum available daily supply. For the purpose of benefiting by the results already brought to light, it will suffice to assume that a maximum of 200 million gallons can be availed of, in which case the draught will be double what it is now. In order to maintain a daily delivery of 100 million gallons, it has been necessary to impound nine thousand million gallons, while to maintain double this delivery it is computed that the storage must be increased to thirty thousand million gallons, or something more than threefold. If then the influence of a comparatively limited storage manifests itself by checking the progress of the whole region, what will be the measure of the injury when the reservoirs attain three times their present volume? Will the banishing power correspond to the increase of draught and exhibit double the force that it has heretofore, or will it follow the ratio of storage and become three or four times as unrelenting?

It is a strange commentary on the municipal government that the work now being prosecuted should depend for such partial success as is possible for it upon the bigness or number of dams, while their existence alone threatens the border of the metropolitan area. Under its various aspects the subject embraces the beauties of politics, hydraulics, and economics. We find the obligations of these sciences indifferently interpreted by the present scheme. The statesman has mistaken the metropolis of to-day for the town of his forefathers, and by copying what they did under the garb of public utility, has instituted a procedure of slow confiscation. The engineer has hidden under the "sheltering fallacy" that the dynamics of malaria is a study for visionaries only; he boasts that fifty years ago the supply looked down on the city, but hereafter the city may look down on the supply! The property owner, hushed into silence by the mystery of the new gravity system, awaits a repetition of the popular rejoicing of 1842!

Looked at from the present horizon, there seems to be a density of atmosphere in the direction of the Croton valley through which the phenomena of the future are, by the familiar parallax, raised into recognition.

HUDSON'S BAY RAILROAD.

The question of the construction of the Hudson's Bay Railroad is now before the Manitoba Legislature, and the government has decided to make an offer to Onderdonk, the New York railway magnate who is now promoting the scheme, backed by several English and German capitalists. About 300 miles of the line will run through Manitoba, and this section of it, Premier Greenway announces, will be subsidized to the extent of \$2,000 per mile by his government. This is \$250 a mile better than the government did for the Northern Pacific, which is now building branches in this country. It is possible the government may be induced to guarantee bonds of the Hudson's Bay road to the extent of \$4,500,000.

RESISTANCE OF PEANUT OIL.

MR. J. J. P. BRUCE WARREN, chemist to the Silver-town India Rubber Company, has discovered that peanut oil possesses some curious properties. This oil is so sensitive to variations in temperature that its resistance rapidly decreases when the temperature rises.

Mr. Warren made some experiments with a test glass containing a little of the oil, into which dipped two silver electrodes, an electric current passing through the oil and a galvanometer. Upon holding the test glass in the hand, he found that the resistance decreased to a considerable extent, solely through the warmth of his fingers. He then proceeded to make other experiments, and found that a wax night light placed at a distance of about 2½ inches from the test glass caused the resistance of the latter to decrease.

Mr. Warren says that it may be asserted, without exaggeration, that a fraction of a degree is immediately shown by the galvanometer, so that the oil might be usefully employed as an electric thermometer.—*La Lumière Électrique.*

THE SILVERTOWN DYNAMO.

THE dynamo which we illustrate is of special interest as having been built to satisfy the Admiralty requirements with regard to heating. The machine is of the ordinary Gramme type, with inverted single horseshoe magnet, and, by the courtesy of the manufacturers, the India Rubber, Gutta Percha and Telegraph Works Company, Limited, we are able to give herewith some of its leading details. The machine shown in our illustration is intended for belt driving, but it will be easily understood that, by replacing the pulley by a coupling, and prolonging the bed plate, this machine can be directly coupled to a Willans engine, and it is this combination which has been supplied to the Admiralty. The armature core consists of naked iron wire thirty-one miles diameter, supported on a metal spider. The core is wound on a special lathe, in which

shunt winding is 11,400 ampere turns. The series winding consists of copper strip $\frac{1}{4}$ in. by $\frac{1}{16}$ in. wide, there being fourteen turns on each limb. The resistance of the series coils is 0.006 ohm, and the exciting power of 5,712 ampere turns. This gives a total exciting power of 17,112 ampere turns. The machine is intended for an output of 200 amperes at 80 volts terminal pressure when running at 400 revolutions per minute.—*Industries.*

PHOTO-LITHOGRAPHIC TRANSFERS.

By W. T. WILKINSON.

THERE are various ways of making photo-transfers, viz., upon paper direct and upon zinc, for subsequent retransfer to stone. The direct method is that most generally used, and for rough, ordinary work answers

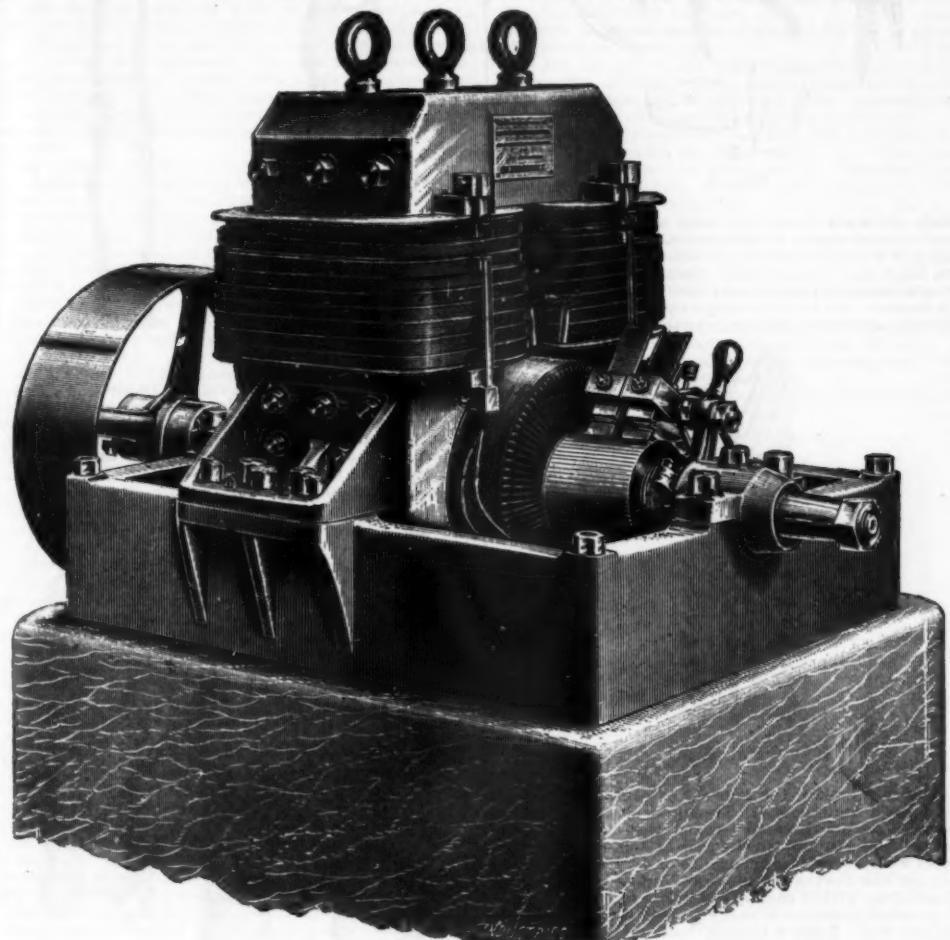


FIG. 1.—GENERAL VIEW.

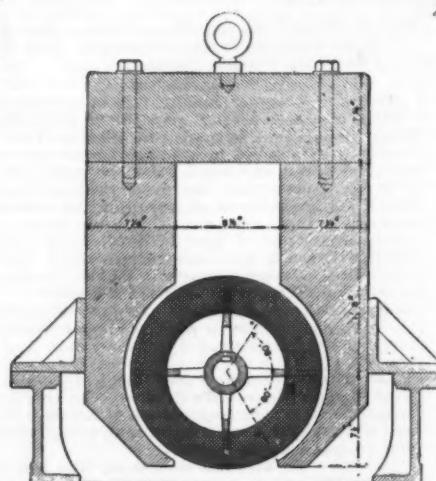


FIG. 2.

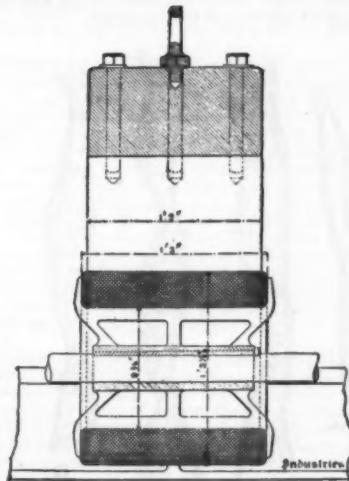


FIG. 3.

THE SILVERTOWN DYNAMO

the wire is guided by an adjustable feed motion, so that the different convolutions are placed close together with perfect regularity. During the process of winding, the intervening spaces between the arms of the spider are filled up with quadrant-shaped blocks, in order that the core may be perfectly circular. The armature conductor is wound by hand, and consists of 160 turns of 19 strand No. 16 cable, which is shaped on the outside into a rectangular or rather trapezoidal section, so as to completely fill the available space. The commutator has eighty sections, and the resistance of the armature when cold is 0.018 ohm. The magnets are of soft, annealed wrought iron, 100 sq. in. in section, and the bore of the pole pieces is $16\frac{1}{4}$ in. in the middle and $16\frac{1}{2}$ in. at the corners. The shunt winding is placed nearest the core, and consists of twenty layers 83 milles wire, each layer containing 74 turns. The total number of turns of shunt wire on both limbs is 2,900, and the resistance cold is 18.6 ohms, and after six hours' run 20.7 ohms. The exciting power of the

very well; but where fine work is wanted with absolute register, scale, and size, then the zinc method must be used.

Line transfers may be pulled from collotype plates, rivaling in sharpness and scale those pulled from zinc. But they require so much longer time preparing than the zinc plates that they are very seldom used for the purpose.

There are several ways of preparing the paper for the direct methods, each of which has its advocates. The paper may be coated with gelatine, chrome alum—a trace—and potassium bichromate, or with arrowroot and bichromate, thus making the paper sensitive with one operation. Paper so prepared is, after exposure, inked up dry and developed in hot water.

Another way is to coat the paper with plain gelatine, dry, then to sensitize by immersion in an aqueous solution of potassium bichromate, soaking the exposed print in cold water before inking up.

The ordinary transfer papers sold for carbon work,

sensitized and developed in the same way, yield very good transfers.

Winstone, Shoe Lane, London, sells Husnik's transfer paper, which is sensitized in potassium bichromate dissolved in a mixture of water and methylated spirits of wine. This paper is inked up dry and developed in cold water. This paper is made by first coating with gelatine and chrome alum, drying, then floating upon albumen, which requires the methylated spirit to coagulate it and prevent its removal during sensitizing.

Bank post paper is usually recommended for photo-litho work, but it is too thin. The best paper is good wove, not laid, paper, from twenty-five to forty pounds per ream.

Inking up the Prints.—The old plan of inking up the prints involves the use of a litho-press in the dark room, and is at its best a clumsy and wasteful way of doing the work. The easiest and best way is to use a board like the back of a printing frame, one portion to be say 13x3 and the other 13x15, hinged together; the hinges to be sunk in the wood so that when the board is laid on the table it will lie quite flat. To use this board, raise the board in the middle, insert the edge of transfer in the joint, and the pressure at the hinges will hold it tight. Now on a clean inking slab thin a little photo-litho transfer ink with turpentine, charge a glue and treacle roller, then ink up the print, rolling from the hinges only, continuing the rolling until the turpentine has evaporated, when there should be a thin, even coat of ink, through which the image can be faintly seen. One of the points upon which a beginner stumbles is the inking up of dry transfers—the usual plan being to crowd on as much ink as possible, the consequence being that the print smears in development.

In inking up a wet transfer, place a piece of thick blotting paper on the board. Place the wet transfer upon it face up, fix in the joint, blot the surface with either blotting paper or a soft cloth. Then having charged the glue roller with thin ink, roll the print one way only until the whites clear, leaving the lines forming the image standing out firm and black. A gentle rub with a pedge of cotton wool well charged with water will remove any serum left on whites, and the transfer is hung up to dry.

Photo-litho transfers should be dried at as low a temperature as is possible, else the gelatine coat will be made brittle, and the ink made too dry to give a solid transfer. For photo-litho transfers on zinc, thinner metal is used than for etching, as better contact is obtained over large surfaces, as well as being easier to handle.

The zinc must be well polished with very fine emery cloth and turpentine, then immersed in a weak bath of nitric acid, alum, and water, ten drops of nitric, ten grains of alum to a pint of water. This is put into a tray, the zinc immersed, and the tray rocked until the polished surface of zinc gives way to a fine matt. The plate is now removed and well washed, the scum being removed by rubbing gently with a pedge of cotton wool. The plate is now put into a whirler and coated with albumen, then whirled, coated again, whirled again, then dried over a small spirit stove. The albumen is composed of white of one egg, water eight ounces, saturated solution bichromate potash one ounce. Beat up the egg, add the water, mix, then add the bichromate solution. This mixture must be well filtered before use.

To get good prints on zinc, a whirler must be used. A film of albumen on zinc, well whirled, requires less than one-quarter the exposure of a film not whirled. Unwhirled films are uneven, one portion of plate having no film and another portion having a film too thick, through which the light, not having penetrated, washes off in development.

Inking up after exposure is effected with a glue roller, charged with thin ink, care being taken to get a very thin, even coat of ink all over the plate. From these prints upon zinc the transfers are pulled on litho-transfer paper and then retransferred to stone. The transfer to stone is best intrusted to a skilled lithographer, especially by beginners, as careless or ignorant transferring will spoil the very best photo-transfer.

Do not try photo-litho or any of the photo-mechanical processes with makeshift appliances, but get proper tools first, then the work will be easy and pleasant, and the results good.—*Br. Jour. of Photo.*

ON WOOL AND FUR, THEIR ORIGIN, STRUCTURE, CHEMICAL AND PHYSICAL PROPERTIES, AND COMPOSITION.*

By WATSON SMITH.

I.

Wool and the different kinds of fur and hair covering certain classes of animals, such as sheep, goats, rabbits, and hares, we may generally discriminate from one another in that wool differs from fur and hair, of which we may regard it as a variety, by being usually more elastic, flexible, and curly, and by possessing certain peculiarities of surface structure conferring upon it the property of being more easily matted together than are fur and hair. Yet this attempted definition needs to be cautiously advanced, for the fact is, as Dr. Bowman, our greatest authority, observes in his work on the wool fiber: "The difference between wool and hair is rather one of *degree* than *kind*, and all wool-bearing animals have the tendency, when their cultivation is neglected, to produce hair rather than wool. Wool and hair, fur being intermediate, are simply modifications of the same root substance, and the scales of the wool fiber have a much larger free margin than is the case with hair, being only attached to the stem for about one third of their length, and in many cases the free ends are more or less turned outward, so as to present a much more serrated edge than is the case with hair. The interior portion of the fiber, however, does not differ in the least from that of hair, and can neither be distinguished from it chemically nor microscopically."

Fig. 1 shows a section of the skin with a fiber of wool rooted in it. Here we see that the groundwork, if we may so term it, is fourfold in structure. Proceeding downward, then, we have, 1st, the outer skin, scarf skin, or cuticle; 2d, a second layer of skin called *rete mucosum*, forming the epidermis; 3d, the papillary

* Read before the Chemical Club, December 4, 1888.

layer; 4th, the lowest or corium layer, forming the dermis. The peculiar globular cellular masses below in the corium are termed *adipose cells*, and these throw off perspiration or moisture, which is carried away by the sudoriparous glands, which pass independently off to the surface. Other glands terminate under the skin in the hair follicle, which follicle or hair socket contains or incloses the hair root. Now the complex glands referred to, terminating in the hair follicle, secrete an oily substance, which bathes and lubricates as well as

are of great importance to the textile manufacturer. Their character and mode of connection with the cortical substance below makes all the dif-

only step necessary, previous to bleaching; for, as we shall now see, the natural development of well cultivated wool is such that the scales project quite sufficiently for this purpose, whereas in the case of fur for felt hats the fullest development and projection of the scales is necessary to encourage the intimate approach and interlocking needed for a close and hard felt (Fig. 5). This felting is simply a contraction and condensation of the looser fibers to a compact mass by reason of an ever-increased interlocking of inverted fibers, in-

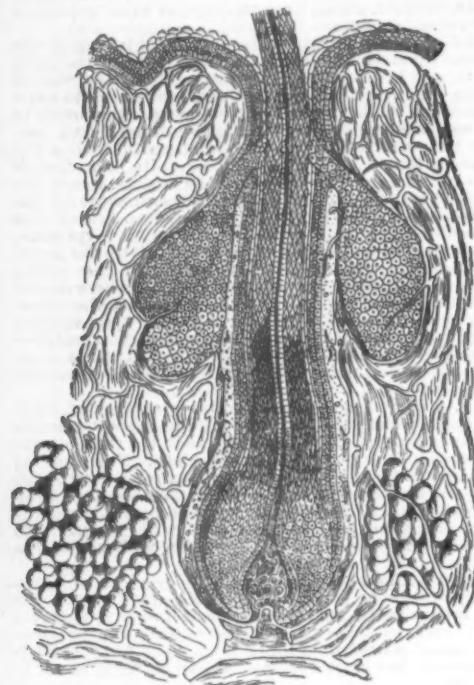


FIG. 1.

nourishes the hair. As regards its origin, this hair or wool fiber is formed inside the follicle by the exuding therefrom of a plastic liquid or lymph, and this gradually becomes granular. It is then formed into cells, which, as the growth proceeds, become elongated into fibers, and form at length the central portion of the hair. Just as with the trunk of a tree we have an outside dense portion, the bark, and an inner less dense and more cellular, and then an inmost portion, which is most cellular and porous, so with a hair the central portion is loose and porous, the outer more and more dense. Glancing at the figure (Fig. 2) of the longitudinal

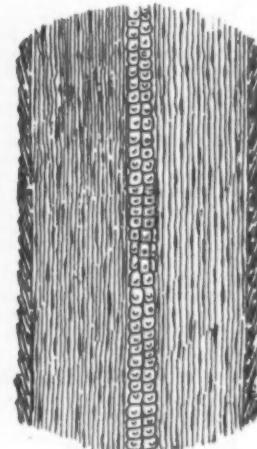


FIG. 2.

section of a human hair, we observe first the outer portion like the bark of a tree, consisting of a dense outer sheath of flattened scales, then comes an inner lining of closely packed fibrous cells, and frequently an inner well marked central bundle of larger and rounder cells, forming a medullary axis. The transverse section shows this exceedingly well (Fig. 3). The end of a hair

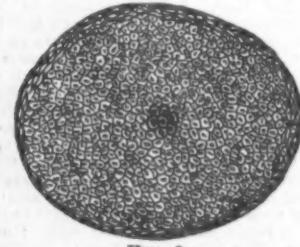


FIG. 3.

is generally pointed, sometimes filamentous. The lower extremity is larger than the shaft, and terminates in a conical bulb or mass of cells, forming the root (Fig. 1).

In the next figure (Fig. 4) we are supposed to have separated these cells, and above, A, we see some of the cells separated from the central pith or medulla, and fat globules; between, B, some of the intermediate elongated or angular cells, and below, C, two flattened, compressed horny scales from the outer portion of the hair. Now these latter flattened scales at the surface



FIG. 4.

difference between wool and hair, and so determines the extent and degree of that peculiar property of interlocking of the hairs known as felting (Fig. 5). We observe that the very structure described indicates the very considerable porosity of wool and fur fibers, and their capacity for being cleansed by proper agents from all greasy and other matters between scales and pores.



FIG. 5.

Let us now look at the general external structure of a hair, say a human hair. The upper or free edges of the scales are all directed toward the end and away from the root; in fact, in the case of some of the more perfect wool fibers the appearance under the microscope is almost like that of a number of minute cups inserted and piled up within each other. The fact of the peculiar serrated structure is easily proved by a simple mechanical test. Take a human hair, place it between finger and thumb, and gently rub it by the alternate motion of finger and thumb together. The hair will then invariably move in the direction of the root quite independently of the will of the operator.



FIG. 6.

When a hair or wool fiber is in its natural state, and hence with its pores full of natural grease and its surface more or less lubricated, it feels smooth and soft, also on looking at it through the microscope its scales are not always easily discernible as scales, but look like lines or markings. There are several ways of making this scaled surface perceptible to the touch, and the scales, as scales, perceptible and plain under the microscope. Moreover, since this development of the scaled structure is an important condition for the milling and felting processes, in which it is of equal importance that the integrity of the surface (the smoothness and polish of the scaled surface, the smoothness, too, of the edges of the scales, etc.) be preserved as much as possible, so that final quality of the woolen or felt goods known as a good finish may be obtained in the highest possible degree, we have to inquire as to the most harmless means of attaining the one without injuring the other. It is clear that the use of a solvent to remove the grease, oleates, and natural salts, without dissolving or corroding the fiber, is the first natural step.

In the case of wool for spinning and weaving it is the

duced by processes of beating, "bumping," vibrating under pressure, etc., and the fuller projection of the scales is brought about by treatment preferably with acids, since alkalies exert a too considerable solvent and corrosive action. I will now show you on the screen samples of the finest merino wool fiber (Figs. 8, 9, and 10), and of various specimens of fur.



FIG. 8.



FIG. 9.



FIG. 10.

FIG. 8.—Finest Merino Wool Fiber. FIG. 9.—Wool Fiber Showing Typical Structure. FIG. 10.—Wool Fiber from Chinese Sheep.

There is a saying among felt manufacturers that "Dead wool won't felt." By this I understand wool from animals that have died of disease. It is now interesting to observe how diseased wool appears under the microscope, and this I will show you on the screen (Fig. 6). You see there the mystery revealed and solved. The fibers are attenuated, irregular, the scale markings and edges almost disappeared in some places, and generally scanty and meager in development, and hence felting with such fiber must be imperfect. (See Fig. 6.) Such diseased wool is nearly as bad as "kempy" wool, in which malformation of fiber has occurred. In such kempy, as Bowman shows, scales have disappeared and the fiber has become in part or whole a dense non-cellular structure, resisting dye penetration and felting. (See Fig. 7.)

Let us now consider the chemical composition of wool, fur, and hair. We shall best do this by considering apart: (1) the composition of the pure fiber itself, and (2) that of the substances, fats, saline compounds, and grease associated with it.

Pure fiber of wool has something like this composition in 100 parts: carbon = 49.25 per cent., hydrogen = 7.57 per cent., oxygen = 23.66, nitrogen = 15.96, and sulphur = 3.66 per cent.

As regards the sulphur, it is difficult to look upon this as an integral constituent of pure wool fiber, since it is removed to a greater or less degree by most solvents, and in different wools the variation has been found to be from 0.75 to 3.8 per cent.

Based on the fact of the presence of sulphur is a method for discriminating wool fiber or fabric from those of silk or cotton.

Plumbite of soda, when boiled with wool, at once blackens it, while silk and cotton are not blackened.

Based on this fact, moreover, are the old methods of dyeing the hair black with lead solutions, though at the risk of introducing lead into the system, followed by colics and contractions of the limbs.

For the quantitative determination of wool in presence of silk and cellulose fibers, a useful reagent is basic zinc chloride, made by dissolving 100 parts of fused zinc chloride with four parts of zinc oxide in 85 parts of water, at a boiling heat, until a clear solution is obtained. This solution dissolves silk slowly in the cold, quickly if hot, and forms a thick, gummy liquid. Wool, fur, and vegetable fibers are not affected by it. But another solvent is required for removing wool or fur, and that is caustic soda solution, especially if hot. Vegetable fibers remain undissolved.

Vegetable fibers are easily removed from silk and wool by a mere soaking in dilute sulphuric acid of about 3° Tw., followed by drying. The cellulose fibers are destroyed and converted into mere dust, which can be removed by shaking or beating out the dust. In strong sulphuric acid, cotton and cellulose fibers are dissolved, especially on gently warming; wool is but little affected, and certainly not dissolved; silk is at once dissolved, even in the cold. Addition of water to the cellulose and silk solutions causes only dilution of the clear liquid; but addition of tannic acid, while leaving the cellulose solution unaffected, precipitates in a curdy form the fibroin from the silk solution. A solution of oxide of copper in ammonia dissolves cotton and silk, but not wool, and from the cellulose solution a solution of sugar or gum precipitates the cellulose, while no precipitation is effected in the solution of the silk. The following solvent finally is efficacious for silk, while leaving cellulose fiber and wool undissolved. Sixteen parts of copper sulphate (crys.) are dissolved in 150 parts of water, and to the mixture are added 16 parts by weight of glycerol. The mixture is then treated with a solution of caustic soda until the precipitate first formed is just redissolved.

From these data, schemes for quantitative estimation in mixture of cellulose fibers, wool, and silk can readily be constructed.

In dyeing certain shades and colors on wool, it is sometimes necessary to remove as much of the sulphur as possible from the fiber, and Chevreul, I believe, introduced the method of steeping in milk of lime, washing with water, weak hydrochloric acid, and water again, with several repetitions of the process. Silk differs from wool, among many other things, in containing no sulphur, but it contains about 18 per cent. of nitrogen. Hummel gives the amount of mineral matter in wool, free from yolk, as 0.08 to 0.37 per cent. This consists chiefly of phosphates and silicates of lime, potassium, iron, and magnesia.

Wool that has been fully cleansed from foreign matter has a chemical composition very similar to that of feathers or horn. The name keratin has been given to such substances. Dr. Knecht, of Bradford, has been endeavoring to isolate from wool the substance which unites so readily with coal tar dyes and other dyestuffs to form apparently beautiful lakes in the fiber. This substance, he argues, is a basic one, since acids and acid coal tar colors and color acids are all absorbed and retained after washing. Moreover, by treatment with sulphuric acid, he has apparently removed this substance by solution. This solution he filtered and found that it forms, with most of the acid coal tar colors, richly colored lakes, or precipitates. By neutralizing the sulphuric acid solution with NaOH, he obtained a curdy precipitate of the substance.

But we have been speaking of the purified fiber. Let us now ask what proportion this bears to the impurities associated with it in the raw wool. With such a structure as that which we have seen wool possesses, it can be no matter of surprise if the greasy matters, natural oily substance, saline matters, etc., stowed away behind and around those numerous scaly envelopes, should amount to a very considerable proportion. Such is indeed the case. When dry sheep's wool is treated with very dilute hydrochloric acid (0.18 per cent. HCl), ether, water, and alcohol successively, and then again exhausted with alcohol and ether, all the soluble ingredients are removed and the insoluble matters left can only be separated mechanically. The ether dissolves the fat, the water the wool sweat, principally consisting of the potassium compounds of oleic and stearic acids, etc., and the alcohol, what of the preceding the other solvents leave.

In some cases the loss thus obtained amounts to from 30 to 50 and up to 70 per cent. of the air-dried wool.

Again, another surmise may be very properly grounded on the peculiar structure of the wool fiber, viz., that such fiber is very likely to absorb moisture readily and retain it persistently. This is the case, and little attention has been paid to it in England, as Dr. Bowman and Professor Hummel point out. On the Continent a manufacturer will not buy wool as wool, and official public testing establishments are situated in all the principal centers in Germany and France.

According to Bowman, the water in wool is there in two conditions: (1) As moisture; and (2) as water of hydration, or water really belonging to the fiber in its natural state.

He has determined the latter by drying wool at 38° C., and then exposing it to the air at from 10° to 16° C. He then found that the amount of moisture regained was about 8.4 per cent. However, though mentioning that the amount of water absorbed depends on the amount in the air, Bowman does not here state the hygrometric condition of the air at the time. I understand that the condition of the atmosphere is so critically considered by practical men, that some wool staplers in Bradford will not sell after an east wind has been blowing for some days. However, the average loss at 100° C. is 14 per cent., but it is not unattended with some decomposition, and the fiber is turned yellow. This means a further loss of 5.2 per cent. in addition to the 8.4 per cent. This wool exposed to the air regained much of the loss, but not all, showing that injury to the fiber had commenced.

On the Continent it has been found that if exposed to a temperature verging upon that which would cause scorching of the fiber, it will regain 18 to 18.5 per cent. of the moisture.

J. Persoz finds that while at 130° to 140° C. wool fiber is completely disintegrated, when moistened with a 10 per cent. solution of glycerol, it remains unaffected at this temperature (*Monit. Scient.*, July, 1887).

Chevreul, after determining in wool dried at 100° C. the earthy matter, suint, and neutral fats, found that only 31.4 per cent., or less than one-third, of pure textile fiber remained. Dr. E. Knecht finds a similar amount of fiber in a sample of greasy Russian wool.

Chevreul's analysis of raw merino wool, after drying at 100° C., gave him of—

	Per cent.
Earthy matter deposited by washing the wool in water	26.06
Suint or yolk, soluble in cold distilled water	32.74
Neutral fat (soluble in ether)	8.57
Earthy matter adhering to the fat	1.40
Wood fiber	31.23
	100.00

Generally, it may be said, the finer qualities of wool (merino) contain more yolk ("suint") than the coarser kinds.

Now, as regards this yolk and the part it plays in the nourishment and growth of the wool, Youatt says: "The filament of the wool has scarcely pushed itself through the pore of the skin, than it has to penetrate another and singular substance, which from its adhesiveness and color is called *yolk*. It is found in greatest quantity about the breast and shoulders, the very parts that produce the best, healthiest, and most abundant wool; and in proportion as it extends in any considerable degree to other parts the wool is then improved." The fineness, strength, and luster of the fiber depend upon this natural defense, lubrication, and nourishment combined.

In a determination of the constituents or analysis of raw wool, Hummel, in his "Dyeing of the Textile Fibers," gives the following outline:

(a.) *Moisture* is determined by drying at 100° C. in a stream of hydrogen (inert gas).

(b.) *Wool fat* by extraction with ether, thereby removing also the oleates, subsequently removed by shaking the ether solution with water. The ether solution contains the *wool fat*, the aqueous the *oleates*.

(c.) Residual wool is repeatedly washed with cold distilled water; more oleates are thus extracted. They are mixed with those from the ether; see (b). The wool is then washed with alcohol. More oleates are thus extracted, and their weight is added to those from the aqueous solution. Earthy oleates left in the wool are decomposed by weak hydrochloric acid. The acid is removed by water, the wool dried and treated with ether and alcohol. On evaporating the solvents named to dryness, residues are obtained from which the amount of earthy oleates can be reckoned.

(d.) The wool is finally dried and well shaken, and teased out over paper, to remove dirt, sand, etc. When washed on a fine sieve the wool is dried and weighed, and the sand and dirt taken by difference.

Marecker and Schulz, using the method sketched above, obtained the following results:

	Wool of Lowland Sheep.	Wool of Full-bred Rambouillet Sheep.	Pitchy Wool.
Moisture.	Per cent. 23.48	Per cent. 12.28	Per cent. 18.28
Wool fat.	7.17	14.66	34.19
By successive treatment:			
Soluble in water (wool sweat)	21.13	21.88	9.76
Soluble in alcohol	0.25	0.55	0.89
" in dilute HCl.	1.45	5.64	1.39
" in ether and alcohol.	0.29	0.57	...
Pure wool fiber.	43.20	20.83	32.11
Dirt.	2.93	23.64	8.38
	100.00	100.00	100.00

Wool fat is not a compound of glycerol, and consequently is not a true fat. It is separable into two portions by treatment with boiling alcohol; the lesser soluble and the larger insoluble. The soluble part contains chiefly that at once alcohol-like and fat-like body *cholesterin*, which is a carbinol, along with *ischolesterin*, while the insoluble part contains principally these latter bodies combined with oleic acid, and in small quantity with stearic and other fatty acids.

So-called "pitchy wool" contains much wool fat, which is difficult to remove by scouring with mild alkalies.

A method issued by the Fab. Chem. Prod. Acte. Ges. of Berlin, of separating the constituents of commercial wool fat (C. D. Abel, Eng. pat. 396, January 8, 1886) is based on the fact that the raw product is soluble in carbon bisulphide, benzine, benzol, xylenes, toluene, isobutyl, alcohol, or any alcohol, but from its solution in these all the soaps (*sic*) are completely precipitated by addition of acetone. The fatty acids of commercial wool fat can be separated from the wool fat by converting them into alkali soaps by adding alkalies, and then treating the whole with ethyl or methyl alcohol. With the aid of heat all is dissolved, but on cooling the wool fat separates, leaving the soaps in solution. The easiest plan is to treat the raw wool fat with ammonia and then with alcohol. The ammonia soaps dissolve and leave the wool fat, which, after emulsifying with water, forms *lanolin*.

A more recent method by Langbeck and Ritsert (Eng. pat. 6,210, May 7, 1886) is to treat raw wool fat, freed from water and dirt, with boiling alcohol containing about 10 per cent. of ether, the warm alcoholic solution of the free fatty acids, free cholesterol and isocholesterol and volatile ethers of the fatty acids containing also a small quantity of cholesterol fats are separated from the undissolved cholesterol fats. The alcohol is removed and the cholesterol fats distilled off by superheated steam. Another way was to dissolve the whole wool fat in ether and precipitate the cholesterol fats alone by addition of alcohol. This method is applicable direct to the lyes from wool-washing works.

I understand in these methods that raw wool fat which have been already separated from other matters are taken, but I also think the fact called attention to by Hummel, p. 92 of his "Dyeing of Textile Fibers," has been much overlooked by chemists, and inventors too, viz., the soaps (oleates) are not perceptibly soluble in the volatile agents proposed, CS₂, ether, and petroleum spirit, etc., but only bodies of the nature of fats. Hence washing with water must always follow.

Wool sweat.—The portion soluble in water has been shown by Chevreul, Vauquelin, Hartmann, etc., to contain principally the potassium salts of oleic, stearic, hydric, and other fatty acids, along with others in smaller quantity of potassium with valerianic and acetic acids, and also phosphates, sulphates, chloride of potassium, etc. Ammonium salts are, moreover, present in small quantity.

It is not necessary to call attention to the great value of the constituents of the suint and salts. 1st. As regards the potash. 2d. The possibility of making ferro- and ferri-cyanides from them. 3d. As a source of lanolin and cholesterol—for this has already been

done in papers published in this *Journal* by Ivan Levinstein, 1886, 578-580, and W. Bott, 1883, 123-124. Hummel also gives a useful account of it in his *Dyeing of Textile Fibers*, pp. 40-43.

Quite recently (*Compt. Rend.*, 107 (20), 789-792) A. and F. Buisine have discovered in suint, and isolated from it, glycolic acid and normal pyrotartaric acid, COOH. CH₂.CH₂.CH₂.COOH (normal propylene dicarboxylic acid) a higher homologue of succinic acid (COOH.CH₂.CH₂.COOH). They are contained in the portion of suint soluble in water. These savants have already isolated benzoic, succinic, and malic acids. The following list of acids is given as derived from fermented suint: The fatty acids from acetic to capric; the hydroxy acids of the foregoing, glycolic and lactic acid, and their acid amides, glycolic, leucin, the bishydroxy acids, oxalic, succinic, and normal pyrotartaric, a hydroxy acid of one of the preceding bishydroxy acids, malic acid, with some others, as hippuric, benzoic, and uric, etc. These acids exist principally as potash salts. Acetic acid amounts to 60 per cent. of all the other acids present, and Buisine hopes to recover it industrially. In northern France alone 1,000,000 kilos. should be obtained annually.

Action of Acids.—Dilute acids have little effect on wool, i. e., sulphuric and hydrochloric acids, whether hot or cold. The scales on the fiber are, however, opened out, and hence felting promoted. The fiber also becomes harsher; harshness of feel is often alleged as a criterion of damage to the fiber, but it may not be so at all, for if you cleanse the fiber with CS₂, or benzol perfectly, and then with cold water, you get a certain degree of harsh feel simply because the oils and fats are completely removed from the surface of the fiber, and the scale edges become more sharply developed. A microscopic examination, however, clearly shows when serious modification of the fiber has taken place.

Furriers use as a stimulant to the fiber scales acid solution of mercuric nitrate, but they often use it so strong that the fur is stained yellow and made excessively harsh. In such cases it is undoubtedly injured, and no good finish can be got upon felt made from such fur. Figs. 11 and 12 respectively illustrate fur fibers

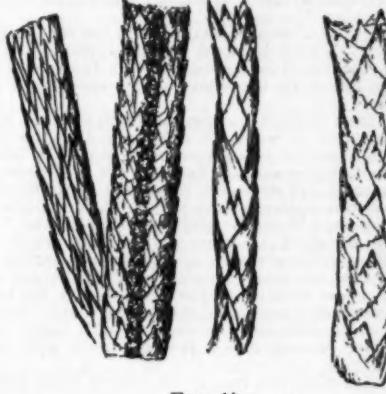


FIG. 11.

from different parts of the same animal (hare) before and after the treatment described. The figures, of course, represent the microscopic appearances.

Cellulose is, of course, very sensitive to sulphuric acid, which disintegrates it. The felt manufacturer removes cellulose particles or burrs from his felt by steeping in dilute sulphuric acid, drying, and then



FIG. 12.

beating out the dust of the disintegrated and partially carbonized cellulose. Nitric acid is also used for stripping wool of its color previous to redyeing. Thus indigo-dyed wool may be "stripped" with nitric acid of 3°-4° Tw. Sulphurous acid is the best bleaching agent for wool, removing its natural yellow color. Dr. Knecht has shown that when boiled with dilute sulphuric acid, wool absorbs from 2 to 3 per cent. SO₃H₂, which are only removed by long continued boiling with renewed quantities of distilled water. Part is removed as ammonium salt.

Action of Alkalies.—Alkalies, which have little effect on cotton, have to be used very dilute and with great caution on wool. Alkaline carbonates in solution and dilute, also at a temperature not above 50° C., have little action on wool. Soap and carbonate of ammonia have less injurious action still. If a soda ash with causticity in it be used, the damage is certain. The temperature of any solution used in the case of wool is an important matter, for even hot water is injurious. Dr. Bowman finds that "wool which looked bright when well washed with tepid water became duller when kept in the water some time at a temperature of 71° C. and the same wool, subjected to boiling water at 100° C., became quite dull and lusterless." When the water at 71° contains only very small quantities in-

deed of alkali," adds Bowman, "the whole of the surface of the wool, and indeed its substance, is dissolved into a jelly-like mass." Dr. Knecht finds that wool will dissolve in a solution containing less than five per cent. of its weight of NaOH at boiling temperature. I have here micro-sketches of a human hair before and after treating with warm dilute alkali (Figs. 13 and 14).



Before treatment with alkali.



After the treatment.

FIG. 13.

FIG. 14.

You will observe the projecting and jagged edges of the scales (Fig. 14), indicating corrosion and injury. The same fibers that carried before boiling with water alone 500 grains without breaking, broke after boiling with 480 grains.

In the drying of wool in chambers in the carbonizing process, 121° C. may be used provided the vapors escape, for the rapid evaporation cools the wool, heat becoming latent in the steam at the expense of the fiber.

We see then that pitchy wools and rich merinos, richest, respectively, in wool fat and yolk, i. e., the very finest wools, will be those needing most care in scouring with alkalies or soaps. Yet they are just the wools requiring most and strongest treatment to rid them of the extraneous matters of the yolk. Thus manufacturers have looked about for other scouring agents.

Carbon Bisulphide.—Among them are what are termed the volatile scouring agents, such as carbon bisulphide, fuel oil, ether, petroleum spirit, benzol, etc. However, these volatile bodies are solvents for fatty matters, and not for alkaline oleates and soaps. Hence, in conjunction with them, a washing with water must be combined, so as to follow the treatment with volatile liquid.

Bisulphide of carbon has, so far, among these agents received the most favor, as it so very readily dissolves the wool fat, even in the cold.

Bowman says: "Bisulphide of carbon dissolves the suint and fat of wool very easily and completely, without injury to the fiber. The bisulphide may then, when removed from the wool, be driven off at a steam heat, leaving the unchanged fats behind as a residue." However, fine soaps are not removed, and it is a fact that bisulphide of carbon, if hot, leaves the wool yellow, and bleaching will not remove that yellow color, for it is due to sulphur deposited in the fiber.

Hummel (p. 101, "Dyeing of Textile Fibers") says the use of volatile liquids has not yet met with much acceptance, but that the difficulties attending their use have been more or less overcome by Da Heyl, Van Haecht, and others, more especially by T. J. Mullings, yet the process of the latter, who employs throughout a low temperature, is not an unqualified success. A friend of mine who has witnessed and inspected it in operation, tells me that the water run off into the river after the washing which followed the CS₂ treatment had a dreadful odor, and made the river smell for some distance. However, if properly purified by rectification from half-slaked quicklime in powder, it has little or no odor.

Benzol and petroleum spirit have the serious objections that they are specifically lighter than water, and so can neither be so easily displaced by water from the fiber, nor be sealed by a layer of water kept above their surface. Combined with this great mechanical and statical advantage of CS₂, we have the additional one of its volatility, though this, as we shall shortly see, is by no means an advantage under some circumstances.

I have in this paper endeavored to explain the physical and chemical structure and properties of wool fiber and its natural accompaniments, so as to prepare the way for the consideration in the next of the advantages of a rational treatment of the raw wool with a volatile and inert solvent in the cold, along and alternately with water, over the treatment at present in vogue with warm dilute alkalies in the process known as scouring, and I hope to be able to prove to you that a new process just invented and patented by my friends, Messrs. Singer and Judell, fulfills all the demands made by a rational treatment. The apparatus for this new process is now being constructed by Messrs. Mather & Platt.

(To be continued.)

A CORRESPONDENT of the *British Medical Journal* tells of a drunken doctor in the Alleghany Mountains, who, when in a state of semi-drunkenness, took a piece of ammonium carb. out of his surgery bottle and chewed it. The effect was almost magical. The contents of the stomach were quickly ejected, the usual depression not following, so that he was able to at once resume his debauch. The remedy has been tried many times since with great success. The drunkard can generally be roused and got to swallow $\frac{1}{2}$ drachm of ammon. carb. dissolved in a wineglass of water, which drunk off will prove immediately effective as an emetic and restorer.

PRINCIPLE OF FORCE AND DEMONSTRATION OF THE EXISTENCE OF THE ATOM.

By HUDSON MAXIM.

CO-EVIDENT with consciousness of our existence are certain truths.

Truth is the exact accordance with that which is, has been, or shall be.

Self-evident truth is that accordance with being which is too simple to require demonstration.

Complex truth is that accordance with being whose evidence requires demonstration.

A complex truth established upon self-evident truths is a concomitant certainty with the primary truths themselves.

There is no difference in truth. Self-evident truth is what, with all conditions necessary to its determination as absolute, is at once within consciousness of certainty. What truth is self-evident to one mind may not be so to every other. The greater the mind, the greater the truths that become self-evident. Some truths that are self-evident to the mind of a Newton, a Darwin, a Spence, may be far beyond the comprehension of ordinary mortals. An axiom is any self-evident truth.

SELF-EVIDENT TRUTHS.

Axiom 1.—A thing cannot, at the same time, be and not be.

Axiom 2.—That which exists as a composite whole, its parts, as units of the whole, also exist.

Axiom 3.—The whole is greater than any of its parts.

Axiom 4.—Every whole is equal to all its parts taken together.

Axiom 5.—If any part be taken from a whole, there remains such a part of the whole as has not been taken.

Axiom 6.—Division of a body is not annihilation of the body.

Axiom 7.—Nature extends without limit in all directions and contains all bodies, all space, all causes, and all effects.

Axiom 8.—No two solid bodies can occupy the same space at the same time.

Axiom 9.—An absolute solid completely fills the space occupied by its dimensions of extension.

Axiom 10.—No absolute solid can occupy more space than is equal to its dimensions of extension.

Axiom 11.—No absolute solid can occupy less space than is equal to its dimensions of extension.

Axiom 12.—An absolute solid cannot pass through the same space at the same time that it is occupied by another absolute solid. (Axiom 8.)

Axiom 13.—If an absolute solid be taken from a given space, there remains an absolute void of dimensions of extension equal to the solid body taken.

Axiom 14.—Motion is alteration of position or changing of place.

Axiom 15.—Force is any action between bodies which changes, or tends to change, their relative condition as to rest or motion.

Axiom 16.—There exists a certain something which we call matter.

Axiom 17.—There exists an attractive force between different portions of matter which we call gravitation.

ARGUMENT.

Let us take the word nature, as best suited to our use, and consider the term as embracing in its meaning all space, all matter, all causes, and all effects.

It is self-evident that nature must be either all an absolute void or an absolute solid, or consist of both, perfect solids and void spaces.

Nature cannot be all an absolute solid, for in that case all motion were impossible. (Axiom 12.)

Nature, therefore, must be either all an absolute void, or consist of perfectly solid portions of matter and void spaces where matter exists not. (Axioms 9, 10, and 11.) One of these two alternatives must be true. (Axiom 1.)

Nature cannot be all an absolute void, for in that case all force and all motion were impossible; for if nothing existed, there would not be anything to move, or anything for force to act upon, or between. And motion and force are as stated in Axioms 14 and 15.

Hence the only alternative left is that nature embraces spaceless solid units of substance and absolute void where substance exists not. For to demonstrate existence impossible except as claimed, of what is known to exist, proves the truth of the claim.

But let us argue this point a little further.

Let us take at the ordinary temperature of the air, what is termed a solid iron ball or sphere.

Now, it is self-evident that the sphere in question must be either all an absolute solid, or all an absolute void, or consists of both absolute solids and void spaces.

If we heat the sphere, we find that it expands, increasing its dimensions of extension in all directions; and on cooling again, we notice that it contracts to its former dimensions as it reaches its former temperature.

During these alterations in size we find that the weight or gravitational force of the sphere toward the earth remains unchanged. Hence the quantity of matter contained in the sphere is neither increased nor diminished. And, as an absolute solid could neither expand nor contract in size (Axioms 8, 9, 10), we know that the sphere in question cannot be all an absolute solid, but must contain void spaces.

We know that it cannot consist wholly of spaces, or else it would be nothing but void. (Axioms 1, 8, 9, 10.) Hence the sphere must consist of both void spaces and spaceless solids possessing certain dimensions of extension in length, breadth, and thickness.

And the dimensions of extension of all the solid atoms plus the dimensions of extension of all the vacant spaces of any body are exactly equal to the dimensions of extension of the whole body; for the whole must be equal to all its parts (Axiom 4), and must require all its parts to complete the whole.

But it is argued that as we know nothing of matter except through force, force may be either a property of matter or matter be but a property of force.

It is self-evident that force is what it is claimed as being in Axiom 15, and hence cannot have being except in being what it is (Axiom 1)—the action or power of something exerted upon something, or action between two or more things or objects.

Therefore, as force can exist only as a condition of more than one thing, if we take away from the ultimate whole wherein force is considered, all of the parts except one, between which the exertion of force exists, we have one part left (Axiom 5), but no force. What, then, must that part be which is left?

The certainty that it exists (Axioms 1 and 5), the certainty that it cannot be force, the certainty that it can be nothing else, demonstrates that it must be absolutely solid substance. (Axiom 4.)

Let us now conceive of but one of these ultimate solid atoms as existing entirely alone in all space, assuming that it alone be all the matter or substance in existence.

It could have no motion in any direction, for space of itself without limit is without direction, and no place in space could have position relative to the rest of space—hence position and place as relative to but space are impossible, therefore, a single ultimate atom existing alone in space could have no motion, as it could not alter its position, having no position or place to change.

Hence, direction, distance, position or place are terms which relate to conditions of existence of more than one unit of existence or atom, excepting as relates to points within its own dimensions, and being an absolute solid, no point within itself can change its position relative to other points. Hence all motion were impossible with an ultimate atom existing alone in space.

The ultimate solid could have no axillary motion, as no point within its dimensions could alter its position relative either to other points in the solid unit or to space.

The conception of a centrifugal force from an axillary motion, as tending to separate the ultimate atom into parts, is untenable, for the ultimate atom being a perfect solid must also be absolutely unbreakable, as well as absolutely incompressible, as will be more fully shown further on.

A single ultimate solid existing alone in space could possess no attracting or repelling force or power—as there would be nothing for it to attract or repel.

Therefore position, place, force, and motion are conditions of existence of more than one ultimate atomic solid.

If we now conceive of another like ultimate solid atom as existing along with the first, an attracting force, or a repelling force, or both, according to distance, and the concomitant conditions of position and motion are possible.

But it is self-evident that as no change can take place in the ultimate solid, the only effect force is capable of producing, and the only force that is possible to exist, is the changing, or tending to change, the condition of the atoms as to rest or motion relative to one another.

Now, if a single ultimate solid existing alone in all space can possess no force, and in itself is incapable of undergoing any change; and if the addition of another ultimate solid along with it adds force, and the conditions of position and motion being the only conditions possible, if we add an infinite number of atoms we have an infinite force, and by infinite combinations of atoms we have infinite manifestations of force, but necessarily of the same force; as the only possible manifestation of force is in the change of the relative condition of atoms as to rest or motion, as all changes must occur outside of the atom, for the atom is of itself unchangeable.

ANSWERS TO ARGUMENTS AGAINST THE EXISTENCE OF THE ATOM.

The principal arguments against the existence of the atom which I have seen are those advanced by Herbert Spencer and by Boscowich. Spencer, in his "First Principles," page 51, says: "Were matter thus absolutely solid, it would be what it is not, absolutely incompressible, since compressibility, implying the nearer approach of constituent parts, is not thinkable, unless there is unoccupied space between the parts. Nor is this all. It is an established mechanical truth, that if a body, moving at a given velocity, strikes an equal body at rest in such wise that the two move on together, their joint velocity will be but half that of the striking body. Now it is a law of which the negation is inconceivable, that in passing from any one degree of magnitude to any other, all intermediate degrees must be passed through. Or in the case before us, a body moving at velocity 4 cannot, by collision, be reduced to velocity 2, without passing through all velocities between 4 and 2. But were matter truly solid—were its units absolutely incompressible and in absolute contact—this "law of continuity" as it is called, would be broken in every case of collision. For when, of two such units, one moving at velocity 4 strikes another at rest, the striking unit must have its velocity 4 instantaneously reduced to velocity 2, must pass from velocity 4 to velocity 2 without any lapse of time, and without passing through intermediate velocities; must be moving with velocities 4 and 2 at the same instant, which is impossible."

Spencer here bases his argument on what he supposes to be an immutable law of nature: that a moving body cannot pass from velocity 4 to velocity 2—that is, from a given velocity to a velocity half as great at the same instant.

Let us conceive of a body being projected perpendicularly from the earth in such wise that it shall ascend and descend in the same line. It certainly must stop at the point whence it begins to descend, and as it must move at some velocity until it stops, it must pass instantly from velocity something to velocity nothing, which is as great as from velocity 4 to velocity 2.

For, suppose the force of gravitation were instantly removed at the same instant that the ball was moving at its last degree of velocity, the ball would continue to ascend, and however slowly it moved, would travel a given distance, say twelve feet, in sufficient time, and if it moved with only half that velocity, it would travel six feet in the same time.

Now, a velocity of twelve feet in a given time is to a velocity of six feet in the same time as velocity 4 is to velocity 2. Therefore, to stop at all, a moving body must pass instantly from some velocity to some other equally less as from velocity 4 to velocity 2.

Again, suppose we were to project a body perpendicularly from the earth at the rate of a thousand feet per second.

From the moment it leaves the earth, the attraction of gravitation acting upon it, continually retards its

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motion until it stops; and each point throughout the line of its ascent must mark a degree in the reduction of its velocity, and hence it must sacrifice one degree of its velocity in attaining the height of each succeeding point throughout the entire line of its ascent until it comes to a stop.

Now let us project a like body from the earth in the same manner and with equal force; but let us conceive of a gravitational force twice as great, which, acting upon the ascending body with double the retarding force exerted upon the first body, would bring it to rest at half the height attained by the first body.

Hence it must instantly lose twice as much velocity at each point of its ascent as did the first body. It must instantly lose twice as much velocity in the same time as did the other body when acted upon by the lesser gravitational force.

Therefore Spencer's argument amounts to nothing; for what he claims as impossible is so simple a truth that it may well be considered an axiom, as follows:

A moving body encountering a resisting force instantly loses such velocity as is exactly equal to the resisting force it at each or any instant encounters.

The theory of Boscovich is substantially that the constituents of matter are centers of force or ultimate units of force, points without dimensions which attract and repel one another in such wise as to be kept at specific distances apart. That is, that matter is but an attribute of force, instead of force being an attribute of matter.

We have already demonstrated this theory impossible. However, let us for argument's sake conceive of one of these force centers of Boscovich as existing entirely in all space, as we have already considered the ultimate solid.

Now it is self-evident that force as stated in Axiom 15, "is any action between bodies which changes or tends to change their relative condition as to rest or motion," and as a thing cannot be, and not be, at the same time, it is certain that force cannot be, where it can have no effect or tendency to induce change.

Now a single force center or unit of force existing alone in all space must still exist as force if it exist at all, and existing alone, there would be nothing but itself as an object of its action or tendency; and as force can exist only as action or tendency to induce change, the claim that a unit of force could exist alone is untenable, for it could so exist only in action or tendency to produce itself, which already existing would negative the possibility of such action or tendency, and consequently negative the possibility of a unit of force existing alone, and the possibility of any truth in the force center theory.

But it is asked in argument by disciples of Boscovich, if matter be composed of solid units of substance, what is it that holds together the parts of that body if it be not a cohesive force? And if one of these solid bodies were sundered by a sufficient force, what, but a cohesive force, would hold together a fragment into which it might thus be broken? And so on until we come to centers of force without any dimension.

Division of a body is not annihilation of the body, and no matter how far we carry division in thought, or how far conceive of possibility of carrying it, still a whole must be equal to all its parts taken together; and however infinitely small the parts into which a body may be divided, still the sum of the dimensions of extension of all the parts taken together must equal the dimensions of extension of the original whole; and thus any part, however small, must have dimensions of some extent.

The fact is, our ideas of breaking and separating of bodies are but our impressions from associated ideas. Could we possess infinite powers of vision, we would see that what we deem breaking of substance is in all instances but a moving apart of different substances, the same as the moving of a stone from the earth by lifting the stone, and that absolute fracture or breaking into fragments of absolutely solid substance is not in the course of nature or range of possibility.

We have come to reason inductively that all things must be breakable by the application of a sufficient force, and that some force must be sufficient.

Let us see about this. Suppose we conceive of an absolute solid, a perfect sphere in form and of sufficient size to be tangible to our senses.

Let us apply to every part of its surface a force "sufficient" to compress it. It is evidently not compressible. (Axiom 11.)

In the consideration of a force as tending to compress an absolute solid, all forces are equal to one another and hence all equal 0—thus the term sufficient is inapplicable, the same as no time could be sufficient to end eternity, or distance sufficient to extend to the end of space. Nothing could be sufficient to render an impossible?

Let us reverse this force and let there be a force acting upon every point on its surface sufficient to pull an absolute solid asunder; is it not evident that it would be equally as unbreakable as incompressible?

It is self-evident that no force whatever, equally applied to every point of the surface of an absolute solid sphere could compress it. Suppose we reverse that force, and consider force in any degree of amount as drawing equally in all directions outward from every point of its surface, how and where could fracture occur? Being a perfect solid, its cohesive force or tensile strength, if considered in the light of a force or strength, must be absolutely equal throughout every point of its entire dimensions, hence such force could tend to produce no other effect than absolutely equal expansion throughout its entire dimensions. That is, it must expand so that no one point or portion shall be more solid or rarefied than any other—that is, it must expand and still retain itself a perfect solid, which is impossible. (Axiom 10.)

SUMMARY OF DEDUCED TRUTH.

First.—All matter exists in ultimate atomic units of absolutely solid unchangeable substance.

Second.—With but one ultimate atomic solid existing alone in all space, all force, motion, or change of condition would be impossible.

Third.—With but two or three ultimate atomic solids existing alone in all space, attraction, or repulsion, or both, according to distance from one another, would be the only possible forces that could exist. And the only possible change that could be wrought by these forces in the condition of these atoms would be a

change of their conditions as to rest or motion by changing their positions relative to one another. Adding any number of atoms adds no new force, neither makes any new force the more possible, but increases the possibilities of the same force directly as the squares of their numbers, and inversely as the squares of their distances from one another.

Fourth.—The sum of all the forces of all nature at the present moment is exactly that of the sum of gravitational force and of the momentum acquired by its ultimate atomic solid units in their nearer approach to one another, occasioning the passage of matter from a rarer to a denser form.

Fifth.—All events of all history, and all phenomena, and all evolutions of organic and inorganic, animate and inanimate nature during all time, have been exactly those which have resulted from the sum of the combined forces of all the atoms in existence acting upon one another.

Sixth.—Every atom in existence follows a course mathematically exact—that which is determined for it by the combined forces exerted upon it of all the other atoms in existence. And every atom in existence follows a course as mathematically exact under the combined influences exerted upon it as do the heavenly bodies.

Seventh.—Could all the atoms in existence be instantly placed in exactly the same position relative to one another that they occupied just one thousand years ago, possessing the same acquired momentum they then possessed, every heavenly body would again pass through exactly the same change of position relative to one another that they have passed through during the last thousand years, and all would again at the end of one thousand years be in exactly the same positions that they now occupy. And the same with every earthly event, everything would reoccur in the history of men exactly the same, and all things reoccur exactly the same and in the same order as they have occurred during the last thousand years, and we should again all be here, the history of all our lives be the same, and we should all again be actuated by the same influences which determine us to work our own destiny without changing the nature of a single atom or swerving one from its destined course.

There can be no effect without a cause, and there can be no cause which is not itself an effect of a preceding cause. Every effect is a cause for effects exactly equal to itself.

There can be no more effects in nature than are exactly equal to producing causes. And there can be no more causes for effects than is exactly equal to the effects to which nature owes those causes, which are the causes of those causes.

The ultimate atom is the unit of measure of power in all effects.

SCIENCE AT BREAKFAST.

By JOHN MICHELS.

THE sterling goodness of Dr. Johnson's heart, notwithstanding many apparently blunt demonstrations to the contrary, was never more clearly demonstrated than when he remarked to Boswell, "I encourage this house, for the mistress of it is a good civil woman, and has not much business."

The house referred to was the "Turk's Head Coffee House." But coffee houses, nay coffee drinkers, have much changed in outward form since the days of the sturdy old philosopher. The bean and the belle no longer, in picturesque costumes, discourse scandal sipping the Eastern beverage from exquisite specimens of china ware, and tea and coffee, no longer a luxury, are now enjoyed by the toiling millions, and esteemed a blessing by all classes.

Although tea and coffee is universally used by the civilized nations of the world, few understand the natural potent properties of these substances, or even are conscious of their powerful action upon the human system, and as it is a subject interesting to so many, I offer the following sketch, treating of the more important points:

Coffee, tea, and chocolate all contain in common a nitrogenized basis, to which they owe most of their important chemical properties. Tea and coffee even contain the selfsame basis, denominated indiscriminately *theine* or *cafeine*. In chocolate the cocoa principle called *theobromine* is richer in nitrogen than the *theine*.

The chemical constituents of these substances are as follows: While in tea the basis is combined with tannic acid, in coffee it forms a salt, with a peculiar tannic acid containing a greater proportion of nitrogen, which together with tannic-caffie acid is united with potash into a so-called double salt. Tannic-caffie acid when roasted develops the agreeable odor of coffee.

Not only the same basis, but also two similar organic acids, one contained in tea, the other in coffee, increase the conformity between the leaves of the former and the beans of the latter.

Legumin, cellulose, gum, sugar, citric acid in addition to oleine, and what is called palm fat, accompany the organic acids and the *theine* of the coffee beans.

But the tea leaves, apart from the basis and the acids, are composed of albumen, cellulose, gum and wax, the green pigment of the plant and the volatile oil of tea.

This peculiar oil is the principal source of the aroma of tea, by which, in spite of the conformity between tea and coffee, it essentially differs from the latter.

The inorganic constituents of tea and coffee are moreover different. While, in coffee, chlorine, phosphoric and sulphuric acids are combined with potash, lime, magnesia, and oxide of iron, tea contains another inorganic acid besides, consisting of manganese and a large proportion of oxygen.

So much for the chemical constituents of coffee and tea. Let us now examine their peculiar properties and nutritive qualities.

Chocolate, from its large proportion of albumen, is the most nutritive beverage, but at the same time, from its quantity of fat, the most difficult to digest. But its aromatic substances strengthen the digestion. A cup of chocolate is an excellent restorative and invigorating refreshment even for weak persons, provided their digestive organs are not too delicate. Cardinal Richelieu attributed to chocolate his health and hilarity during his later years.

Tea and coffee do not afford this advantage. Albumen in tea leaves, and legumin in coffee berries, are represented in very scanty proportions, for while in the former the albumen is coagulated by boiling water, in the latter the legumin is prevented from being dissolved by the lime with which it is combined.

The praise of tea and coffee as nutritive substances is, therefore, hardly warranted, because, as restoratives for the body, the alimentary principles and not the elements are to be taken into account. The former principle cannot be ascribed to "theine," which is excreted again as urea, with surprising rapidity, and to this swift transformation tea and coffee owe their diuretic action, which is considerably assisted by the warm water of the infusion.

Tea and coffee, though of themselves not difficult of digestion, tend to disturb the digestion of albuminous substances by precipitating them from their dissolved state. Milk, therefore, if mixed with tea or coffee, is more difficult of digestion than if taken alone, and coffee alone without cream promotes digestion after dinner by increasing the secretion of the dissolving juices.

The volatile oil of coffee and the empyreumatic and aromatic matters of chocolate accelerate the circulation, which, on the other hand, is calmed by tea.

Tea and coffee both excite the activity of the brain and nerves.

Tea, it is said, increases the power of digesting the impressions we have received, creates a thorough meditation, and, in spite of the movements of thoughts, permits the attention to be easily fixed upon a certain subject; a sense of cheerfulness and comfort ensues, the functions of the brain are set in motion, the thoughts are concentrated and not apt to degenerate into desultoriness.

On the other hand, tea, if taken in excess, causes an increased irritability of the nerves, characterized by sleeplessness, with a general feeling of restlessness and trembling of the limbs; spasmodic attacks may arise, with difficulty of inspiration in the cardiac region. The volatile oil of tea produces heaviness in the head, first manifesting itself in dizziness and finally in stupefaction.

These symptoms have been called an evidence of a real tea intoxication. Green tea, which contains much more of the volatile oil than the black, produces these obnoxious effects in a far higher degree than the latter.

While tea principally revives the faculty of judgment, and adds to this activity a sensation of cheerfulness, coffee acts also on the reasoning faculties, but without communicating to the imagination a much higher degree of liveliness.

Susceptibility to sensuous impressions is intensified by coffee; the faculty of observation is therefore increased, while that of judgment is sharpened, and the perceptions adopt more quickly certain forms, activity of thoughts and ideas is manifested, a mobility and ardor of wishes and ideas, which are more favorable to the shaping and combination of already premeditated ideas than to a calm examination of newly originated thoughts.

Coffee, also, if taken in excess, produces sleeplessness and many baneful effects very similar to those arising from tea drinking. Coffee, however, produces greater excitement, and a sensation of restlessness and heat ensues. For throwing off this condition fresh air is the best antidote.

Much depends upon the proper roasting of coffee, in which process it loses weight but increases in bulk, two pints of unroasted berries giving three pints when roasted.

Several empyreumatic substances created by roasting produce the reddish or brown color, and the tannic-caffie acid, altered by roasting, produces the aroma; the sugar loses a part of its amount of hydrogen and oxygen, and is thus decomposed into burnt sugar or caramel.

Liebig states that the berries should be roasted until they are of a dark brown color. In those which are too dark there is no caffeine; and if they are roasted black, the essential parts of the berries are entirely destroyed, and the beverage prepared from them does not deserve the name of coffee. This fact should be noted by drinkers of *cafe-noir*.

The berries of coffee when once roasted lose every hour somewhat of their aroma in consequence of the influence of the oxygen of the air, the porosity of the roasted berries allowing it to penetrate easily. Liebig recommended a process by which much of this pernicious change can be avoided. "Strew," says he, "over the berries, when the roasting has been completed, and while the vessel in which it has been done is still hot, some powdered white or brown sugar; half an ounce to one pound of coffee is sufficient."

The sugar melts immediately, and by well shaking, or turning the roaster quickly, it spreads over all the berries, and gives each one a fine glaze, impervious to the atmosphere.

They have then a shining appearance, as though covered with varnish, and in consequence lose their odor entirely, which, however, returns in a high degree as soon as they are ground.

After this operation, they are to be shaken out rapidly from the roaster, and spread on a cool plate of iron, so that they may cool as soon as possible.

If the hot berries are allowed to remain heaped together, they begin to sweat, and when the quantity is large, the heating process, by the influence of the air, increases to such a degree that the coffee is permanently damaged.

In this city I have often observed that coffee is roasted to too high a color, and filled into sacks too quickly, before the process of cooling is complete.

The preparation of coffee as a beverage is accomplished by three processes: First, by *filtration*; second, by *infusion*; and third, by *boiling*.

Liebig states that filtration gives often, but not always, a good cup of coffee. When pouring the boiling water over the ground coffee, if done slowly, the drops in passing come in contact with too much air, whose oxygen works a change in the aromatic particles, and often destroys them entirely.

The extraction, moreover, is incomplete; instead of 20 to 21 per cent., the water dissolves only 11 to 15 per cent., and 7 to 10 per cent. is lost.

Infusion is accomplished by making the water boil and then putting in the ground coffee, the vessel being immediately taken off the fire and allowed to stand quietly for about ten minutes.

This method gives a very aromatic coffee, but one containing very little extract.

Boiling is the custom in the East, and yields excellent coffee. The powder is added to the water when cold, and then placed over the fire and merely allowed to boil a few seconds. The fine particles of coffee are drunk with the beverage. If boiled long, the aromatic parts are volatilized and the coffee is then rich in extract, but poor in aroma.

Further, Liebig gives what he calls the best method. This I produce, not because I think the plan will make a coffee acceptable to most palates, but because Liebig speaks highly in its praise, and states that it is without those heating properties common to most preparations, causing it to be rejected by many in delicate health.

"My method," said Liebig, "is the union of the second and third. The usual quantities of coffee and water are to be retained; a tin measure containing half an ounce of green berries, when filled with roasted ones, is generally sufficient for two small cups of moderate strength, or one so-called breakfast cup; one pound of green berries, equal to 16 ounces, yielding after roasting 24 tin measures (of $\frac{1}{2}$ ounce each) for 48 small cups of coffee.

With three-fourths of the coffee to be employed (after being ground), the water is made to boil for 10 or 15 minutes.

The one-quarter of the coffee which has been kept back is then flung in, and the vessel immediately withdrawn from the fire, covered over, and allowed to stand from five to six minutes.

In order that the powder on the surface may fall to the bottom, it is stirred around, the deposit then takes place, and the coffee poured off ready for use. In order to separate the dregs more completely, the coffee may be passed through a clean cloth, but generally this is not necessary and often prejudicial to the pure flavor of the beverage.

The first boiling gives the strength, the second addition the flavor. The water does not dissolve more than the fourth part of the aromatic substances contained in the roasted coffee.

The beverage when ready ought to be of a brown black color, somewhat like chocolate thinned with water; this want of clearness in coffee thus prepared does not come from the fine grounds, but from a peculiar fat resembling butter, about 12 per cent. of the amount the berries contain, and which, if over-roasted, is partly destroyed.

In the other methods of making coffee, more than half of the valuable parts of the berries remains in the grounds, and is lost.

"Judging," said Liebig, "as favorably of my coffee as I do myself, its taste is not to be compared with that of the ordinary beverage, but the good effects which my coffee has on the organism should be taken into consideration.

"Many persons who connect the idea of strength or concentration with a dark color fancy my coffee to be thin and weak, but these were at once more favorably inclined when I gave it a dark color by means of burnt sugar."

Adulteration of coffee sold in a ground state is largely carried on, especially of that sold to the poorer classes; out of 34 samples purchased by an English analytical chemist in London, 31 contained chicory, chicory itself being adulterated with all manner of compounds.

There is no falling back, says Dr. Hopall, upon tea and chocolate, as these seem rather worse off than the coffee. Tea is not only adulterated here, but in China; while as to chocolate, the processes employed in corrupting the manufacture are described as "diabolical." It is often mixed with brick dust to the amount of 10 per cent., other 13 per cent., and peroxide of iron 22 per cent., and animal fat of the worst description, while the names "Flake," "Rock," "Granulated," "Soluble," "Dietetic," are merely employed as disguises to cover the fact that they are compounds of sugar, starch, and other substances.

The microscope is the most effective instrument in the work of detecting adulterations, the microscopic appearance of coffee and chicory being very distinctive, while the presence of starch granules discovers the particular cereal employed in adulterations.

The adulteration of coffee by the addition of chicory is fraudulent, but harmless, chicory containing little that is injurious to the system; coffee indeed is the more active substance of the two; its effects on some delicate constitutions being so strongly manifested, that without a violation of language it may almost be designated a weak poison.

Some persons positively like the flavor of chicory, others detest it; its presence, however, can be at once detected by its peculiar odor, and if thrown into cold water it imparts a deep tint, which coffee does not.

In conclusion, I offer a useful receipt of Liebig's for preparing coffee in a ground form for special cases, such as marches and journeys, where it is inconvenient to be burdened with the necessary machines for roasting and grinding; by this process its aromatic properties can be preserved.

One pound of the roasted berries is reduced to powder, and immediately wetted with a syrup of sugar, obtained by pouring on three ounces of sugar two ounces of water, and letting them stand a few minutes.

When the coffee powder is thoroughly wetted with the syrup, two ounces of finely powdered sugar are to be added, mixed well with it, and the whole is then to be spread out in the air to dry. The sugar looks up the volatile parts of the coffee, so that when it is dry they cannot escape.

Ground coffee prepared in this way, and which lay exposed to the air for one month, yielded, on being boiled, as good a beverage as one made from freshly roasted berries.

I have described the mental influence of tea and coffee; much could be written on their influence upon modern society and civilization.

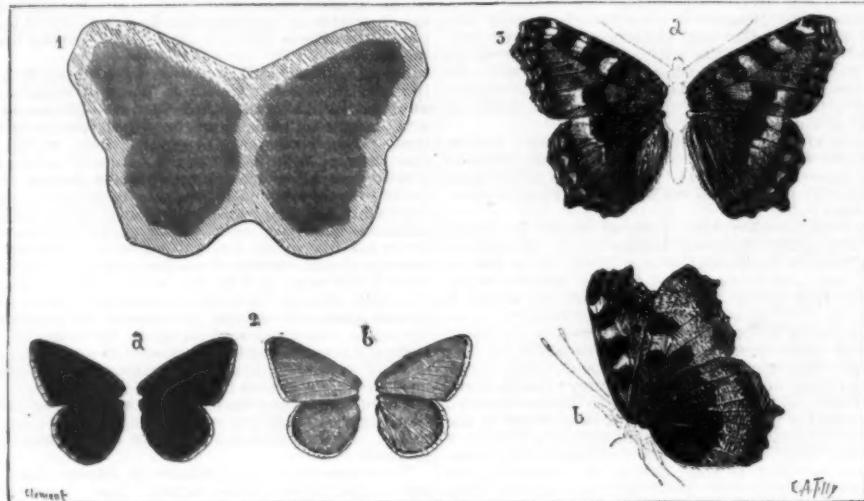
Anne Boleyn makes mention in one of her letters of having partaken of half a pound of bacon and a quart of beer for breakfast; now, after making due allowance for custom and habit, it must be confessed that modern ladies must rise from their morning meal of a cup of coffee with some bread and butter and an egg with many different sensations and sentiments to those experienced by the fair queen after her more masculine repast.—*Health.*

LEPIDOCHROMY.

LEPIDOCHROMY, or the decalcomania of butterflies, consists in fixing the colors of the latter's wings upon paper. Impressions of the same can likewise be obtained upon porcelain and glass. The operation, about which there is nothing complicated, requires merely care, patience, and some skill. After a certain amount of practice has been acquired, it is possible to get up pretty albums of the various species of butterflies that one has been able to procure. Although such collections have not a great scientific value, they at least have the advantage of not being subject to the attack of insects and of not being as fragile as the delicate insects whose effigies they preserve.

It has not appeared to us to be without interest to give briefly a little practical advice upon the processes to be employed. The brilliant colors of butterflies' wings, as well known, are due to minute scales of various forms, the more or less imbricated assemblage of

completely changed, a brownish black butterfly, for example, appearing upon the paper of a beautiful changeable blue. This phenomenon is due to the nature of the wing scales, the color and structure of which are different according to the surface, and in such an impression, which is negative and provisional, there has been obtained only the aspect of the internal layer of scales placed upon the paper in a position reverse to the natural one that they occupied upon the wing membranes. A second operation therefore becomes necessary, and recourse must now be had to varnish in order to obtain the final image of the insect. The best material to use is the spirit varnish employed by photographers, and this must be so thick as not to soak into the paper. Dip a badger's hair brush into the varnish and lay a thin coat of it upon the impression which has been previously obtained, and which, by careful trimming, has been deprived of the margin above mentioned. Then place thereon a sheet of velum paper or Bristol board, in such a way that the



FIGS. 1, 2, AND 3.—LEPIDOCHROMY.

No. 1. The light parts of the figure show the surface of the paper covered with gum; the shaded parts show the contour of the wings. No. 2a. Wings of a blue butterfly blackened by gum. b. The same restored to their original color. No. 3a. Impression of a small Vanessa, with outlines of body to be filled in with paint. b. Three-quarter view of the same butterfly.

which forms the velvety and sometimes changeable shades that many exhibit.

It is these scales that it is a question of fixing upon paper by means of some substance that will hold them.

To obtain an impression of a butterfly, we begin by preparing a solution of very pure gum arabic with the addition of a little rock candy, salt and alum. This solution should have the consistency of a very thin syrup. An excellent fixing material is obtained from the mucilage furnished by the plantain seed, to which is added sugar and gum arabic.

The mucilage (whatever be the kind adopted) is spread with a brush over white paper (foolscap, for example), and upon this are laid the four wings that have been detached with the greatest care by means of sharp scissors (Fig. 1).

Between the wings a space the exact size of the body is preserved, and any position desired is given them, a or b for example (Fig. 3). Upon covering the whole with a second sheet of gummed paper, we shall obtain in one operation both the upper and under surfaces of the insect.

Then the whole is placed between several folds of blotting paper, and put under pressure. Weights, large books, etc., may be used as a press. A copying press or small joiner's press (Fig. 4) gives good results.

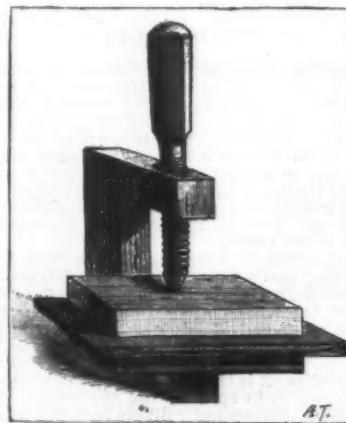


FIG. 4.—SMALL PRESS FOR BUTTERFLIES' WINGS.

The pressure should be continued for a long time (twenty-four hours, for example). After this the two sheets, which are now firmly adherent, are to be taken out and cut in such a way as to leave but a narrow margin around the wings, the relief of which is quite visible. Here, if necessary, the outline of the wings may be traced with a sharp pencil, the paper being placed against a window pane, so that the light may shine through it. The margin thus formed is wet with the greatest care by means of a brush, and the sheets will then separate very easily, each bearing a perfect imprint of the wings. It now only remains to remove, with a needle, the adhering membranes and veins.

The operator will often be surprised to see the colors

two sheets shall be firmly adherent to each other throughout the entire surface of the impression. Then place under pressure, and wait until the varnish is so hard that no blisters will form. This takes but a short time.

Next, take the two adhering sheets from the press and place them in a basin of water, and leave them therein until the paper is thoroughly soaked. Then take them from the bath, and with the point of a needle or the blade of a penknife gently lift the paper, which, through the dissolving of the gum, will easily become detached from the Bristol board. As the varnish is insoluble in water, the scales will adhere to the Bristol board. Now carefully wash the impression with a very soft camel's hair pencil, and then dry it and put it under slight pressure, along with blotting paper, until all the humidity has disappeared. There will thus be obtained upon the sheet of Bristol board a faithful and unchangeable image of the butterfly.

It is now necessary to draw and paint the body and antennae in water colors or water body colors. With some little patience and care, we shall, in the end, obtain in this way a sufficiently exact reproduction. If the butterfly has a thick, hairy body, such as is found in the sphinxes, noctuelles and bombyces, an effort may be made, by means of varnish, to fix along the outline of the body the hairs that have been shaved off with a very sharp penknife. If the insect is still fresh and soft, the skin may even be removed from the back and fixed to the Bristol board; but nothing here is as good as water colors. By the same process, the blank spaces that may exist upon the surface can be filled in.

The reproduction thus obtained may be preserved in an album; it is well, however, to interpose a protecting sheet of tissue paper between them. If it is desired to protect the images still better, a thin coat of spirit varnish may be passed over them.

This method is applicable to all butterflies except those that have white wings. After getting an imprint of these, the wing scales become blackish and produce a bad effect. The reason of this is that every scale is formed of three plates, the last of which, resting upon the membrane, alone possesses the property of reflecting colors. In the first impression obtained with gum water, reproducing the scales in inverse order, the reflecting plate is uppermost. It is therefore only in the counter impression that the blue color will appear, but, in order to obtain such a result, it is necessary that the upper plates shall be perfectly intact. Now, these are always more or less charged with the gum that served to obtain the second impression, and it is therefore necessary to remove this by allowing the Bristol board impression to remain in water for several hours, and afterward by thorough washing. The color, which is greenish on coming from the bath, resumes its blue tint in drying (Fig. 2). The more delicate the blue is, the longer the paper should remain in the bath.

Impressions of blue butterflies must not be varnished, as the application of varnish would give them that dull blackish shade that so much trouble has been taken to get rid of.

ADVICE TO LOVERS OF NATURAL HISTORY ON COLLECTING BUTTERFLIES, PROCURING AND PRESERVING CATERPILLARS, ETC.

Although the use of a net enables a collector to form a collection quickly, it must be admitted that the specimens often become damaged; the wings of the butterflies, with their minute scales, which produce such a beautiful variation of color, are very easily injured

among the grasses and shrubs on which they live. Raising butterflies is a much better system. The most beautiful and perfect specimens may thus be procured. There are two methods, hunting for chrysalides and raising caterpillars. The former are usually found at the foot of trees, under the bark, or at the foot or under the coping of walls. Every season of the year is suitable for hunting. The amateur collector should provide himself with a pick like one of those shown in Fig. 5, Nos. 1 and 2, and then search under bark of old

are ready to mature, whether they are found in the earth or in wood, the amateur should resist any idle desire to examine the specimen, and should place him in his box and await his natural development. The cocoons should be placed in the box as nearly as possible in the same position as they had been found in. If they are found in twigs or branches, they should be attached by threads to the sides of the box. In case this is not done, the butterflies will probably be badly developed, with their wings creased and imperfect.

The collector must, above all, have a great amount of patience, and must not expect that a chrysalis gathered in the winter must necessarily come out in the spring, for it often happens that some of the large night butterflies do not leave their shell for two or three years, and sometimes even longer.

Another disappointment awaits the collector. Often on a warm day he will hear a commotion in the hatching box, and, on examining it, will discover coming out of the cocoon not a beautiful, delicately winged butterfly, but a coarse four-winged fly. It will probably belong to the class of hymenopterous insects.

Chasing butterflies is very good as far as it goes, but hatching them from cocoons is much preferable. Collecting these is a matter that requires much attention, and does not consist in gathering the caterpillars which are accidentally found upon the plants and roads, but a knowledge of what the different species live on when hatched is necessary. It is also necessary to learn their habits. Some are night caterpillars, sleeping during the daytime at the foot of trees or under stones, and creeping about the scrub and flowers at night. Others live in fruits, or hollow roots, or bore holes in the trunks of trees.

The apparatus of a collector should consist of a white tin box like No. 3, or a large white iron box, No. 4. Some use a wooden box with compartments, which is slung over the shoulder. Leaves upon which the insects feed are collected and carried in a suitable bag.

It must not for a moment be supposed that the caterpillar should be kept in a closed box without light, without air, and without nourishment. By no means. On the contrary, the opposite conditions should be fulfilled. They should be kept in a spacious box, well ventilated, well lighted, and with plenty of nourishment. A good type of box consists of a wooden box with the sides or top made of netting, and the bottom filled with earth and sand, to the depth of about two inches, to give the caterpillars room to dig in if they wish to bury themselves, and with a layer of moss on the sand. Fig. 6, No. 1, represents a special type of box. The small caterpillars are raised in flower pots half filled with earth and covered with one of those gauze covers used in summer to keep flies away from eatables. See Fig. 6, Nos. 2 and 3. The flower pot may also be covered by a pasteboard cylinder covered by gauze (see No. 4). In order to keep the food of the caterpillars fresh, the end of the branch or plant is inserted in a bottle placed inside of the pasteboard cylinder, whence it can be readily removed to be refilled. The object is to change the water without disturbing the cocoons that are buried in the earth. To prevent the caterpillars from falling into the water a bottle is procured, having a narrow neck, and linen or cotton is wrapped about the branch, or a cork having a hole for the stem of the branch may be used. The plants ought to be frequently changed, and the box ought to be kept scrupulously clean, as the excrement from the caterpillars might produce mould, which would be injurious to the cocoons. In a case of this kind the receptacle is sprayed with lye. Fig. 6, No. 5.

Berce recommends in raising night caterpillars that a flower pot be about three quarters filled with good earth, and that a sod be placed on it, which should be

in test tubes, with a stopper at the end and with a few leaves for food. Fig. 6, No. 6.

As long as the weather is favorable they should be kept in the open air, but they should not be exposed to the rain, or snow, nor to a high wind, nor to too hot a sun.

The greatest enemies of the caterpillars are the hymenopterous parasites belonging to the ichneumon, bracon, or chalcidion family or small flies. Fig. 7, Nos. 1 and 2. These insects lay eggs on the caterpillars or in their bodies, and when the larvae are hatched they gradually work into the caterpillar, which usually dies before chrysalizing, while in its side lies the silken cocoon of the ichneumon or the pupa of the barillet. Some chrysalize, but die without bringing out a butterfly, while the parasite escapes as described. Many caterpillars are troubled with a fungus parasite (*Isaria farinosa*), see Fig. 7, No. 3. Every collector ought to have books on the history of each caterpillar, butterfly, chrysalis, cocoon, and their parasites as well.

The chrysalides are preserved dry without changing in shape, but caterpillars have to be specially prepared. Some collectors preserve them in alcohol, which without doubt is the best method, but they may also be blown.

This is done by first squeezing out the entrails, by rolling a glass wand over the body. The caterpillar is then but an empty skin, and flat. A straw is inserted in the arms and a thread bound around the skin, which is prevented from slipping by means of a pin. By blowing through the straw the original shape and appearance of the caterpillar is restored. Fig. 7, No. 5. During these operations a cylinder or cornucopia of metal has been raised to a red heat, and the skin is dried inside of this, the blowing being continued and care being taken not to burn the skin. Once dried, the skin retains its shape, and is ready to be put in the collection after the straw has been cut off, an end being left with which to pin the specimen in the box. Some collectors cunningly paint the caterpillars with oil colors, but this is very difficult and seems unnecessary. Others, who do not like the effect of the caterpillars that have been blown, which, in fact, do not much resemble larvae, empty the skins and then fill them with wax which has been given any desired color. Fig. 7, No. 7. If the colors are delicate, all the detail of the figures and bands is reproduced. The effect is excellent.—Maurice Maendron, in *La Nature*.

[JOURNAL OF THE SOCIETY OF ARTS.]

CANES AND STICKS USED IN THE MANUFACTURE OF WALKING STICKS, UMBRELLA HANDLES, ETC.

By J. R. JACKSON, A.L.S., etc.

THERE are few trades probably that have developed so rapidly as that which has for its operations the conversion of rough sticks of all kinds into fashionable walking sticks, umbrella and sunshade handles. Forty—or even twenty—years ago, but little was known about the trade, and even now few people have the slightest notion from whence come the sticks they carry or how they are manipulated into the very many varied forms we now see.

At the early date mentioned above, the stock in trade of a walking stick maker was very limited. Among English produce, the ash and oak were the principal sticks used, while foreign sticks consisted of partridge and Tonquin canes and bamboos. At the present time there is, comparatively speaking, no limit to the material that can be turned to account for the purpose of walking and umbrella stick making; indeed, there is always a keen look out being kept up for new sources of material, and a constant introduction of novelties, both in the sticks themselves as well as in the adaptation of them to meet the demand of fashion. So great, indeed, and so varied and numerous are these demands, that of late years, especially in Continental countries, many persons have taken up the cultivation of sticks of certain kinds, exclusively to supply the walking stick market. In this country land is generally of too high a value for it to be placed under such a system of culture, though quite recently large quantities of ash saplings, in which the roots have all been directed in one way to form what is known as crossheads, have been grown in the county of Surrey.

Nearly twenty years ago the first collection ever got together illustrating the materials used for walking sticks was presented to the museum of the Royal Gardens, Kew, and quite recently this collection has been entirely revised and augmented by the same firm which originally presented it, namely, Messrs. Henry Howell & Co., of Old Street, St. Luke's. I am indebted to these gentlemen, not only for giving me permission to inspect their factory, and for much information contained in this paper, but also for their kindness in furnishing reports on any new materials that have from time to time come under our notice at Kew.

To give an idea of the extent of the work carried on, I may mention that the floor space of the factories covers an area of nearly an acre in extent, and that over 400 workpeople are employed, about 50 of which are occupied in gold and silver mounting. The buildings devoted to the storage of the raw materials are necessarily very extensive, and consist of four floors, on which are classified the various English and foreign sticks as they are imported or brought in from the home forests; and although the thousands upon thousands of sticks here deposited have all been carefully and individually selected for the purposes of the trade, they appear, in the bulk, more suited for firewood than for any other purpose.

Forest produce from all parts of the world is here deposited. From the East and West Indies, Singapore, Java, China, and other Eastern countries, are derived a great variety of sticks, principally, however, belonging to the bamboo and palm tribes. The sticks, as required for the workshops, are drafted from these immense stores; some are so crooked that they require a great deal of straightening before anything else is done with them, and this straightening process is one of the most interesting and remarkable. On the top of a very hot stove is a heap of sand, in which the sticks are plunged, and kept there till they have become quite pliable. The workman then takes the crooked stick while it is still hot and inserts it into a notch cut in a stout board, placed at an angle inclined from him,

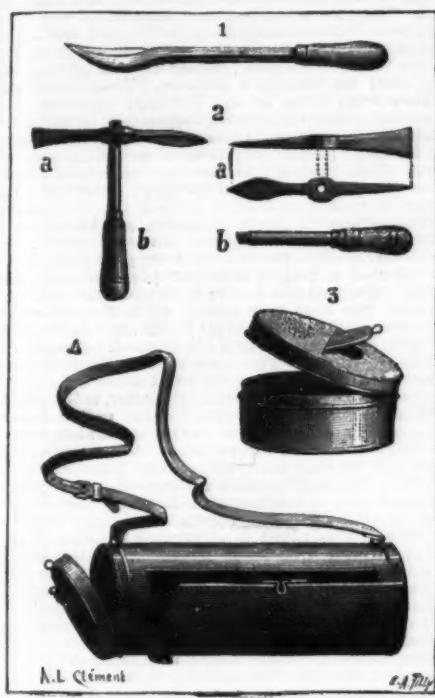


FIG. 5.

No. 1. Ordinary scraper. No. 2. The Clement scraper. a and b. Different views of same. No. 3. Collector's box. No. 4. Box for collecting leaves, etc., with a compartment at the end in which to put caterpillars.

trees and about their roots at a depth of about a foot.

They are more usually found where the trees are planted in soft ground, in which the caterpillars can easily bury themselves before chrysalizing. Some entomologists recommend searching particularly about trees where animals have trodden and broken the turf.

Hunting for chrysalides can be perfectly well done in winter. The amateur who is enthusiastic enough to undertake this will be surprised at the result. Upon removing sections of turf or moss, many lepidoptera and moths chrysalides would often be found.

The specimens thus discovered are put in boxes of wood, or in oval tin boxes having a cover with holes in them, similar to those used by fishermen for their bait.



FIG. 6.

No. 1. Box in which to raise caterpillars. No. 2. Flower pot with gauze cover. No. 3. Cross section of same. No. 4. Another design of same apparatus. No. 5. Spraying tube. No. 6. Glass tube for lepidoptera.

They ought to be put away with care in moss beds, that they may not be disturbed or injured. On reaching home they should be arranged in well-ventilated boxes having a netting over the top and a sand or moss bed, where they are kept until the cocoon is hatched.

In case any chrysalides or cocoons are found which

watered in order to make the grass grow. When covered with the gauze cover, this requires no further attention, except that it be kept in the air and occasionally watered to prevent the grass from dying. Those who collect small lepidoptera often put them



FIG. 7.

Nos. 1, 2, 3. The enemies of caterpillars: No. 1. Ichneumon flavatorius; No. 2. Tachina larvum; No. 3. Isaria farinosa. Nos. 4, 5, 6, and 7. Preparation and preservation of caterpillars, cleaning and blowing.

and bends and strains it, occasionally casting his eye along it to see that it is straight, and when perfectly so it is thrown down to cool, and when cold it is quite rigid, without the slightest fear of its ever going back to its natural crookedness. In this way some of the most irregular and apparently worthless sticks are made to assume an appearance almost impossible, when we consider that the workman has nothing but practice and a well trained eye to guide him. Heat is a very important element in the manipulations of a stickmaker, and produces very different effects on the several kinds of woods, the degree of heat necessary to straighten one kind of stick being often sufficient to completely spoil another kind. The same power which makes a crooked stick straight is applied to make a straight one crooked, and so we find that the rigid stems of bamboo, partridge canes, as well as all the various kinds of English sticks which are required to be curled or twisted, are by the application of heat made to assume almost any shape or form. Thus we often see ladies' sunshade handles, at the present time, especially those of bamboo or partridge cane, twisted and even tied into double knots.

By far the largest number of sticks used are those known as natural sticks, that is, saplings of trees or climbing plants, where the roots have sufficient character to form handles or knots. These are always more in demand, whether for walking, umbrella, or sunshade sticks, than those that are cut from the solid-like letter-wood, ebony, boxwood, beef-wood, partridge-wood, etc. Messrs. Howell, with the view of bringing to light undeveloped resources of which they express themselves as confident that a large number still exist, especially in the Eastern and South American forests, have had some notes drawn up and circulated among their correspondents in all parts of the world. These notes are as follows:

"Points to be observed in collecting raw sticks, canes, etc., for walking sticks, umbrella handles, etc. The total length should not be less than 48 inches, end to end, but if possible they should be 48 inches.

"The best sizes are of the diameter of half-inch to one inch measured about midway, they should not be larger than one and a quarter inches in diameter.

"It is indispensable that the diameter should gradually diminish from the root or handle to the point, so that the stick is not top-heavy.

"It is always better, when possible, to send sticks with some kind of handle; if the plant be pulled up, the root should be left quite rough and untrimmed; if a branch be cut off, a part of the parent branch should be left on to form knob or crutch handle. Sticks without handles can be used, especially if they are nicely grown and have any peculiarity of structure or color; but if there is any handle, however small, it should not be cut off. Young saplings of the different kinds of palms, bamboos, etc., should always have the root left on. Occasionally the form of the root or handle part is attractive, while the stick itself is weak and defective; in such cases, the handles only should be sent, and they should measure from 15 to 18 inches in length.

"In sending specimens of new sticks, it is better to send only small quantities, say one or two dozen, at most, of each kind, then, if approved, further quantities can be asked for.

"Specimens of anything remarkable for form or color, whether in the roots or stems of woody, herbaceous, or reedy structures, should be sent, as sometimes the most unlikely things are found to possess value for use either as umbrella handles or walking sticks."

It will be seen from these notes that, as before stated, the chief demand is for natural sticks, many of which lend themselves readily to the varied designs so necessary for ladies' sunshades. Not many years since the whole of the machinery in use was worked by hand, but in consequence of its being necessary to turn out very large orders with great rapidity, steam power was introduced, which sets in motion band and circular saws, planes and rasps, with the result that a stick of the toughest description can be converted into a marketable article in a very short time. So dexterous do the workmen become in the use of these tools, that they seldom make even the slightest error in their work, and the rapidity with which the workers in gold and silver mounting perform their delicate manipulations is remarkable. Besides the precious metals a great variety of valuable stone mounting is effected in this department, among the stones used being Mexican onyx, agate, jasper, various marbles, and occasionally even the more precious stones, including diamonds. Ivory, horns of all kinds, rhinoceros, buffalo, stag, seahorse, walrus tusks, etc., are also largely used.

In enumerating the materials used in the manufacture of walking sticks it has been thought best to classify them in alphabetical order according to their commercial names. Though the following is a fairly complete list, and represents most of those exhibited in the Kew Museum, it is by no means an exhaustive list, additions being frequently made.

Aoqua.—The name of this stick designates its peculiar coloring rather than its botanical origin, and any stick that is sufficiently strong, and lends itself readily to artificial coloring, is used, such as crab, dogwood, etc.; the specimens at Kew are the produce of a hard-wooded shrub or small tree, found in the forests of Mid and Southern Europe, probably belonging to the dogwood order. The sticks, in their prepared form, have found much favor for ladies' umbrella and sunshade handles. They are made in various shapes, but the color is generally bluish or grayish, with a metallic luster and occasional dark streaks.

Aspe or Asp.—This is the wood of the aspen (*Populus tremula*); it is very light, both in color and weight, and has little else, perhaps, to recommend it for walking sticks. The supply is obtained from our own country.

Ash (*Fraxinus excelsior*).—This tree furnishes a variety of sticks known in trade under different names, as, for instance, the root ash, which consists of the saplings with the roots attached, which form the handle; then there is the crosshead, in which the roots, instead of forming a somewhat globular knob, take a seat at right angles from the stem. These, as has been before stated, have been grown, and so directed during their growth, on a large scale in Surrey during the last two or three years. The figured ash is another form, in which the bark has been scarified into various designs during growth, and on healing has left a permanent marking. These latter are, perhaps, more curious than beautiful,

but still they have their admirers. The ash can be treated in various ways with the bark either left on or removed. Some of those with the bark remaining, when properly cleaned, dressed, and polished, make very pretty sticks, and are not unlike those of the orange.

Bamboo.—The bamboos furnish a great variety and very large bulk of the material used by the walking-stick maker. They come, of course, chiefly from the East, but their botanical sources are difficult to determine. Among those which may be called true bamboos, namely, those furnished by the genus *Bambusa*, may be mentioned the Whampoa bamboo, probably the produce of *Bambusa metake*. They are noted for their irregular jointing; they are of a clean, lemon yellow color, and not long since were much used for sunshade handles. They are imported from China. The yellow bamboo and the black bamboo are also well known, their colors being indicated by their commercial names. These canes are imported from Japan and China, and are no doubt the produce of species of *Bambusa*, as is also probably the beetle cane, so named from its intensely black color and its scaly appearance near the root, which, however, makes it very pretty. This is also the product of a Chinese species. The dog-head bamboo is not a true bamboo, but is furnished by a species of *Arundinaria*, a closely allied genus. The name doghead has been given to this stick from the natural growth of the rhizome roughly representing the head of a dog, so that it is easily carved and converted into good representations of dog's heads. These sticks are imported from China.

Bakou.—This is apparently the produce of a palm, but at present its origin remains unknown. The sticks are imported from Singapore.

Bay Tree or Laurier Thyn.—These sticks are apparently the produce of a species of *Eugenia*, though nothing definite is known about them. The wood is very hard and close grained, almost white in color, but with a cinnamon brown bark covering the irregular root, which makes good handles for umbrellas. They are imported from Algeria.

Beef Wood.—This wood is of a dull reddish color, close and even grained. It is apparently cut from the trunk of a large tree, perhaps that of *Ardisia coriacea*. It is imported from Cuba.

Beetle Cane.—See *Bamboo*.

Birch.—The saplings of *Betula alba*. The roots make good handles, and the supply is obtained from our own country.

Blackthorn.—This well-known hedge plant, known also as the sloe (*Prunus spinosa*), makes excellent walking sticks. There is always a demand for them, for when properly dressed and polished there is no other stick that has so dark a colored bark. Latterly there has been a large sale for a special kind of blackthorn brought from Ireland, and known as Irish blackthorns. They are distinct from the ordinary blackthorn in being flattened instead of cylindrical.

Black Tork.—The botanical origin of this stick has not been determined. It has a dark colored bark, and the root forms an irregular knotted handle. The wood, which is hard and close grained, forms a very rigid stick, revealing, when the bark is taken off, a dark brown wood with occasional light patches. It is imported from the West Indies.

Boxwood, Persian.—This is the true box (*Buxus sempervirens*), the wood of which is so well known as to need no description. The irregularity of the branches recommended it, when peeled of its bark, for walking sticks, and the sticks cut out from the solid trunk make good umbrella sticks, besides which it is often carved into various devices for ladies' sunshades. Another kind of wood, very similar in appearance to true box, but known as West Indian boxwood, is used to some extent for the same purposes. The West Indian boxwood of botanists is *Vitex umbrosa*, but this wood does not agree with that, and at present cannot be satisfactorily identified.

Briar.—This is also the produce of a West Indian tree (*Zanthoxylum Clava-Herculis*), the bark of which is tuberculated, or warted, for which reason it is valued for walking sticks. They are imported from the West Indies.

Cabbage, Jersey.—A well-known variety of the common garden cabbage (*Brassica oleracea*), the stems of which grow in the Channel Islands to a height of ten or twelve feet.

Carob or Caroubier (*Ceratonia Siliqua*).—A branching tree about thirty feet high, native of the Mediterranean coast. The tree is also cultivated for the sake of the pods, which are sometimes known as St. John's bread, or locust, and contain a quantity of saccharine pulp; they are used in Southern Europe for feeding horses, pigs, and other animals, and form one of the ingredients in the concentrated cattle foods. The knotted and irregular branches, when straightened, make excellent walking sticks. They are imported from Algeria.

Carolina Reeds.—These are slender, bamboo-like canes, the produce, apparently, of a species of *Arundinaria*. They are imported from China.

Cedar Wood.—This is the wood of the common pencil cedar (*Juniperus virginiana*). It is only occasionally used, and is too well known to need description. It is imported from North America.

Cherry (*Prunus cerasus*).—Of late years this has become a very important stick, both for walking sticks and sunshade handles. Two distinct forms of the cherry are known in the stick trade, namely, the scented and the tiger cherry. The former has a dark brown bark, which has a peculiarly sweet scent, and in consequence is seldom or never polished, the effect of which would, of course, be to kill the perfume. The tiger cherry has a bark with patches of a beautiful golden luster, which is heightened by the addition of polish. The sticks are imported in large quantities from Austria and Hungary, where the growth for pipes and walking sticks constitutes a staple industry.

Chestnut.—These are the branches or saplings of the Spanish chestnut (*Castanea sativa*). When peeled, the wood is of a very light color, but is hard and durable. The sticks are obtained principally from France.

Coffee.—These sticks are the produce of the ordinary or Arabian coffee tree (*Coffea arabica*), and are brought here from the West Indies. They are very hard and heavy, with a light colored bark, and have but little to recommend them.

Cork.—The produce of the cork oak (*Quercus Suber*). Though these sticks are somewhat clumsy in appearance, owing to the thick and rugged deposit of bark or

cork, they are light in weight from the same reason. They are imported from Spain and Algeria.

Crab.—Two kinds of sticks are furnished by this plant—the wild form of the cultivated apple (*Pyrus malus*), the plainer sticks being known as crab, and the knotted or irregular sticks as warted crab. They are the produce of our own country, though some are imported from the Continent.

Date Palm.—These are the midribs of the leaves of this well known palm (*Phoenix dactylifera*) with the leaflets cut off, rounded and smoothed, and then polished. They are imported from Algeria.

Dogwood (*Cornus sanguinea*).—This is a well known shrub of our own hedges, the wood of which is hard and not liable to splinter; hence it was at one time much used for butcher's skewers. These properties, together with those of rigidity and lightness, have caused the sticks to become very much in favor with walking stick makers. On this account they are much used for the "pillars" or sticks of umbrellas and sunshades, often having other handles or knobs fixed to them. They are imported in large quantities from France, Germany, and other parts of the Continent.

Ebony.—Several kinds of ebony are known in the trade as Ceylon, Macassar, and flowered ebony. The two former are the produce of *Diospyros ebenum* and the latter of a totally different plant, namely, *Brya ebenus*. The first is a native of Ceylon and India, and furnishes the best true ebony, while the second is a small tree, native of the West Indies, and is sometimes known as green ebony and cocos wood, so much used for making flutes. The ebones furnish very choice sticks, which are cut from the solid wood.

Eucalyptus.—This, as its name implies, is the produce of *Eucalyptus Globulus*, better known, perhaps, as the blue gum. It is a native of Australia, but has been introduced into many other parts of the world. The supply for the stick trade comes from Algeria.

Fuller's Teazle (*Dipsacus Fullonum*).—This plant is probably only a cultivated variety of the common teazle found wild in our coopers and hedges (*Dipsacus sylvestris*). The plant is cultivated in some parts of this country, as well as in France and Germany, for the sake of the hooked bracts of the flower heads, which are used for teasing or carding cloth. The adaptation of the stems for sunshade handles is very singular, for most of those used for the purpose are fasciated or abnormally twisted in the process of growth, so that they become double or treble their normal size. This fascination was at one time considered to be unusual in the teazle, and their appearance a few years since in thousands as sunshade handles came as a surprise to the botanist. It exemplified, however, what has been before said, how apparently useless products can be made subservient to the demands of commerce. Teazle stems are imported from France.

Furze, sometimes also known as *Whin* or *Gorse* (*Ulex europeus*).—The stems of this common British plant are, as is well known, very irregular in their growth. When they are straightened and properly dressed, however, they make extremely pretty walking and umbrella sticks, and are in great demand.

Gru-Gru.—These are the saplings of a palm, the botanical origin of which cannot be accurately determined, inasmuch as the name gru-gru is equally applied to *Astrocaryum vulgare* and *Acrocomia sclerocarpa*, both South American species. The sticks are very beautiful, being of a rich dark brown, with fine white longitudinal lines near the joints. The root heads also are very handsome. The sticks are imported from the West Indies.

Guilder Rose (*Viburnum opulus*).—The sticks from this well known shrub are very attractive when dressed and polished. The bark which covers them is of a rich brown, thickly marked with white lines. They are of a comparatively recent introduction, and are very much in demand. They are sometimes known under the name of Balkan rose, being imported from the neighborhood of the Balkans.

Hazel.—This well known stick is the produce of *Corylus avellana*, and has quite recently increased very much in favor both for walking and umbrella sticks. A variety known as silver bark hazel is the most beautiful. The sticks are imported from various places on the continent of Europe.

Holly (*Ilex aquifolium*).—The sticks of this favorite shrub are so much used for walking sticks, whip handles, and similar uses that they need only to be enumerated. They are chiefly the produce of our own country.

Hornbeam (*Carpinus Betulus*).—A well known hard wood tree; the wood is of a very light color, but makes durable sticks. The market is supplied by English growth.

Jambee or *Jambeze*.—This is apparently the produce of palm, which has yet to be determined.

Lancewood.—This wood, supposed to be the produce of *Duguetia guianensis*, a tree of South America, is much used for shafts of carriages, whip handles, and the top joints of fishing rods, in consequence of its elasticity and strength. For the same reason it is used for walking and umbrella sticks.

Loya Canes.—The stems of an Australian palm (*Calamus australis*). They have somewhat the appearance of a rattan, to which they are a close botanical ally.

Malacca (*Calamus scipionum*).—Like the last, these are the stems of a climbing palm, imported, not from Malacca, but from Siak, on the opposite coast of Sumatra. They are a very choice stick, and fetch perhaps the highest price of any stick in the market.

Maple (*Acer campestre*).—The branches of this well known British tree are sometimes used for walking sticks, as well as the wood of its American ally, the bird's eye maple (*Acer saccharinum*).

Medlar (*Pyrus germanica*).—Sticks of this plant are imported from France. They are sometimes covered with numerous transverse gashes, which is done in the stem during growth for the purpose of ornamentation.

Midgen.—This is the stem of an Australian palm (*Kentia monostachya*). It makes a very pretty stick, from the markings or scars of the fallen leaves being very close together.

Mountain Ash.—A well known ornamental tree of our shrubberies (*Pyrus Aucuparia*). The sticks are slender but strong.

Mountain Bay.—A slender palm, the source of which is unknown.

Myall Wood (*Acacia homalophylla*).—A leguminous

tree of Australia, the violet-scented wood of which is well known and has been much used of late in the manufacture of pipes. The sticks are not polished, so as to preserve the scent.

Myrtle.—Whether this is the produce of the *Myrtus communis* is somewhat doubtful. It makes excellent walking and umbrella sticks, which are imported from Algeria.

Nana Canes.—This name has been given to the hollow, reed-like stems of *Arundo donax*, the rhizomes of which form excellent handles for umbrellas and sunshades. They are imported from Algeria.

Oak (Quercus Robur).—The saplings and branches of this well known British tree are much used for walking sticks, and are always in demand. Under the name of Brazilian oak, a stick that has met with a very large demand has been known in the market for some few years. It is corrugated longitudinally, and knotted throughout, the knots being especially thick near the knob. Though this stick is a great favorite, its botanical origin at present is obscure. It is imported from Bahia, and is sometimes known also as Ceylon vine.

Olive (Olea europea).—This is another favorite stick for which there is always a large demand; the dark green bark has a character of its own, and the brown markings of the wood, when stripped of its bark, has much to recommend it. Olive sticks are imported chiefly from Algeria.

Orange.—The orange sticks, which are imported chiefly from Algeria, are probably the produce of other allied species besides that of the common orange (*Citrus aurantium*). The bark of the orange, when dressed and polished, has a bright, greenish color, with white streaks, and makes extremely pretty sticks, for which there is a constant demand.

Orange, Black.—This is a distinct product from the foregoing, and is not furnished by any species of *Citrus*, but by the common broom (*Cytisus scoparius*). The bark has somewhat of the orange marking, but its color is nearly black, as its trade name indicates. It is imported from Algeria.

Palmyra.—These sticks are cut from the solid wood of the palmyra palm of India (*Borassus flabelliformis*). Two varieties are known, black and red, the one with intense black lines, the other with red. The wood is imported from India.

Partridge Canes.—Under this name an immense quantity of canes, with and without the bark, are annually imported from China. Though they are a specially favorite stick for walking, umbrellas, and sunshades, the botanical source still remains unknown. They are largely used for the twisted and curled handles now so much in vogue.

Partridge Wood (Andira inermis).—This is a large tree of the West Indies. The wood is close grained and hard, and takes a good polish; it is used chiefly for umbrella handles.

Penang Lawyer (Licuala acutiflora).—This is a palm, the saplings of which, with the roots attached, are imported in considerable quantities from Penang.

Pimento (Pimenta officinalis).—A tree common in Jamaica, where it is largely cultivated for the sake of its fruits, which are the allspice of commerce. For the stick and umbrella trade large quantities of the young saplings are imported from the West Indies. The sticks are valued specially for umbrella handles, in consequence of their rigidity and non-liability to warp.

Pomegranate (Punica Granatum).—These sticks come mostly from Algeria, where they are specially cultivated.

Rajah Cane.—This favorite stick has been known in commerce for some twenty years or more. It is imported from Borneo, and for a long time after its introduction its botanical origin remained a mystery. It has, however, since been referred to the genus of palms *Eugeissonia*, and probably to the species *minor*. The commercial name rajah is said to be derived from the fact of the duties paid for its export being claimed by the Rajah of Borneo.

Rattan.—Under this name a variety of sticks, apparently the produce of different species of *Calamus*, are known. Thus we have root rattans, white hard barked rattans, monster rattans, miniature rattans, and so on. They are all of a similar character, with the scars of the fallen leaves strongly marked in transverse rings. They are the produce of Eastern countries.

Shakewood (Brosimum Aubletii).—This is also known under the name of letter wood and leopard wood. It is the produce of a large tree, native of Guiana, Northern Peru, Brazil, and Trinidad. The wood is extremely hard, of a reddish brown color, marked with dark transverse blotches. It makes one of the handsomest sticks known, and when mounted with gold has a very rich appearance. A very fine block of this wood is exhibited in the Timber Museum at Kew.

Thistle.—Under this name the stems of the mullein (*Verbascum Thapsus*) are known in commerce. They are slender and very light, both in color and weight; they are, however, very prettily marked, and make good handles for umbrellas.

Tonquin Canes.—These are slender jointed sticks of the character of bamboo, and are the produce of an unknown species of *Arundinaria*. They make light and strong sunshade handles, and are very much used for that purpose. They are imported from China.

Whangee.—This is a well known cane imported from Japan, and is formed of the rhizome or underground stem of a kind of bamboo (*Phyllostachys nigra*). The cane is very pliable, and is very distinctly marked by the transverse scars of the young shoots, where they have died out, and where the rootlets have fallen off. The canes are mostly of a pale yellow color, but there is a variety with black canes known as the black whangee.

Whithorn.—This is another name for hawthorn (*Crateagus Oxyacantha*). The wood is very hard and close grained, and makes very strong sticks.

Zirraco.—A close grained, nearly black wood; used mostly as a cabinet wood. It takes a good polish, and has a very handsome appearance.

From the foregoing notes it will be seen how extensive are the resources of the walking and umbrella stick trade at the present time, and how the forests and jungles of the world are laid under contribution to supply the material.

The following estimate of the annual imports of some of the principal canes from the East here referred to will further illustrate its commercial importance:

Description.	Country.	Approximate quantity.
Bamboos	China and Japan	5,000,000
Partridge canes	China	2,500,000
Tonquin canes	China	20,000,000
Malacca	Siaik	250,000
Whangee	Japan	600,000
Rattan	Singapore	100,000
Other Eastern canes, China, etc.		500,000
		28,950,000

Besides these, the number of various kinds of rattan canes imported from Singapore and other Eastern countries amount in weight to about 1,500 tons, while of sticks other than canes we have of olive, myrtle, orange, and various kinds from Algeria, as many as 2,000,000; and of hazel, dogwood, cherry, etc., from Austria, Hungary, and France, about 3,000,000. The total value of the sticks in the raw state imported from all countries may be estimated at about £300,000.

A NECTARINE TREE CHANGING INTO A PEACH TREE.

An interesting fact has been communicated to the *Comité d'arboriculture fruitière* of the National Horticultural Society of France by M. Lapierre, nurseryman of Montrouge, namely, that last year a Lord Napier nectarine tree in his grounds, instead of producing nectarines, bore nothing but peaches. Making an observation on this report, M. Ferdinand Jamin mentioned that a similar occurrence took place a few years since among his own fruit trees, when a Newington early nectarine tree, without any assignable cause, all at once became transformed into an ordinary peach tree. The dividing line between the peaches and the nectarines is so faintly defined, that sometimes we see nectarine trees bearing a peach here and there among the nectarine fruit proper; and, moreover, when the stones of nectarines are sown in any quantity, some peach trees are invariably produced among the seedlings.—*Revue Horticole*.

HOW RAIN IS FORMED.*

By H. F. BLANFORD, F. R. S.

In certain villages in the Indian Central Provinces, besides the village blacksmith, the village accountant, the village watchman, and the like, there is an official termed the *gapogari*, whose duty it is to make rain. So long as the seasons are good and the rain comes in due season, his office is no doubt a pleasant and lucrative one. It is not very laborious, and it is obviously the interest of all to keep him in good humor. But if, as sometimes happens, the hot dry weather of April and May is prolonged through June and July, and week after week the *ryot* sees his young sprouting crops withering beneath the pitiless hot winds, public feeling is wont to be roused against the peccant rainmaker, and he is led forth and periodically beaten until he mends his ways and brings down the much needed showers.

You will hardly expect me, and I certainly cannot pretend, to impart to you the trade secrets of the professional rain maker. Like some other branches of occult knowledge which Madam Blavatsky assures us are indigenous to India, this art of rain making is perhaps not to be acquired by those who have been trained in European ideas; but we can at least watch and interrogate nature, and learn something of her method of achieving the same end; and if her scale of operations is too large for our successful imitation, we shall find that not only is there much in it that may well challenge our interest, but it may enable us to some extent to exercise provision of its results.

Stated in the most general terms, nature's process of rain making is extremely simple. We have its analogue in the working of the common still. First, we have steam or water vapor produced by heating and evaporating the water in the boiler; then the transfer of this vapor to a cooler; and finally we have it condensed by cooling, and reconverted into water. Heat is communicated to the water to convert it into vapor, and when that heat is withdrawn from it, the vapor returns to its original liquid state. Nature performs exactly the same process.

In the still, the water is heated until it boils; but this is not essential, for evaporation may take place at all temperatures, even from ice. A common little piece of apparatus often to be seen in the window of the philosophical instrument maker, and known as Wollaston's cryophorus, is a still that works without any fire. It consists of a large glass tube with a bulb at each end, one of which is partly filled with water; and, all the air having been driven out of the tube by boiling the water, it is hermetically sealed and allowed to cool. It then contains nothing but water and water vapor, the greater part of which recondenses when it cools. Now, when thus cold, if the empty bulb be surrounded by ice, or, better, a mixture of ice and salt, the water slowly distills over, and is condensed in the colder bulb, and this without any heat being applied to that which originally contained the water. And this shows us that all that is necessary to distillation is that the condenser be kept cooler than the evaporator.

Nevertheless, at whatever temperature it evaporates, water requires heat, and a large quantity of heat, merely to convert it into vapor; and this is the case with the cryophorus; for if the evaporating bulb be wrapped round with flannel, and so protected from sources of heat around, the water cools down until it freezes. That is to say, it gives up its own heat to form vapor. A simple experiment that any one may try with a common thermometer affords another illustration of the same fact. If a thermometer bulb be covered with a piece of muslin, and dipped into water that has been standing long enough to have the same temperature as the air, it gives the same reading in the water as in the air. But if when thus wetted it be lifted out and exposed to the air, it begins to sink at once, owing to the evaporation of the water from the wet surface, and it sinks the lower the faster it dries. In India, when a hot wind is blowing, the wet bulb sometimes sinks 40° below the temperature of the air.

Now this is a very important fact in connection with

the formation of rain, because it is owing to the fact that water vapor has absorbed a large quantity of heat—which is not sensible as heat, but must be taken away from it before it can be condensed and return to the liquid state—that vapor can be transported as such by the winds for thousands of miles, to be condensed as rain at some distant part of the earth's surface.

I have said that the quantity of absorbed heat is very large. It varies with the temperature of the water that is evaporating, and is the greater the lower that temperature. From water that is on the point of freezing it is such that one grain of water absorbs in evaporating as much heat as would raise nearly 5½ grains from the freezing to the boiling point. This is called the latent heat of water vapor. As I have said, it is quite insensible. The vapor is no warmer than the water that produced it, and this enormous quantity of heat has been employed simply in pulling the molecules of water asunder and setting them free in the form of vapor, which is merely water in the stage of gas. All liquids absorb latent heat when they evaporate, but no other known liquid requires so much as water.

Many things familiar in every one's experience find their explanation in this absorption of latent heat. For instance, we feel colder with a wet skin than with a dry one, and wet clothes are a fruitful source of chills when the body is in repose; although, so long as it is in active exercise and producing a large amount of heat, since the evaporation only carries off the excess, no ill consequence may ensue. Again, if a kettle be filled with ice cold water and put on a gas stove, suppose it takes ten minutes to bring it to boil. In that ten minutes the water has absorbed as much heat as raises it from 32° to 212°, an increase of 180°. Now, if it be left boiling, the gas flame being kept up at the same intensity, we may assume that in every succeeding ten minutes the same quantity of heat is being absorbed by the water. But it gets no hotter; it gradually boils away. And it takes nearly an hour, or more than five times as long as it took to heat it, before the whole of the water has boiled away, since all this heat has been used up in converting it into steam. It was by an experiment of this kind that Dr. Black, in the last century, discovered the fact of latent heat, and determined its amount; and it was the knowledge of this fact that led James Watt to his first great improvement in the steam engine.

One more example I may give, which those who have been in India will be able to appreciate, and which those who intend to go there may some day find useful to know. Nothing is more grateful in hot, dry weather than a drink of cold water. Now, ice is not always to be had, but when a hot wind is blowing, nothing is easier than to get cold water, if you have a pot or bottle of unglazed earthenware, such as are to be had in every bazaar, or what is better, a leather water bottle, called a *chhagat*, or a water skin. All these allow the water to soak through and keep the outside wet; and if any one of them be filled with water and hung up in a hot wind, in the course of half an hour or an hour, the evaporation from the outside will have taken away so much heat that the contents may be cooled 20° or 30°, notwithstanding that the thermometer may stand at 110° or 115° in the shade. Soda water may be cooled in the same way if wrapped in straw and kept well wetted while exposed to the wind. But it is of little use to do as I have seen natives do sometimes, viz., put the bottles into a tub of water in a closed room. It is the evaporation that carries off the heat, otherwise the water is no cooler than the air around.

Now to return to our subject. The atmosphere always contains some vapor which the winds have taken up from the ocean, lakes, rivers, and even from the land, for there are but few regions so dry and devoid of vegetation that there is no moisture to evaporate. The quantity of water thus evaporated from large water surfaces is a question of some importance to engineers, who have to take account of the loss from reservoirs and irrigation tanks, and a good deal of attention has been given to measure the amount lost by evaporation. In England it has been found to vary in different years from 17 to 27 in. in the year, or say from 1½ to 2½ in. per month on an average. Now since in the east of England the rainfall is only about 24 in. in the year, it follows that in that part of the kingdom the loss by evaporation from a water surface is not very much less than the rain falling directly on the surface.

In dry countries the evaporation may exceed the local rainfall. In the tropics it has been found to average from 8½ to 6 in. per month in the dry season. In the case of a large tank at Nagpur, constructed to supply the city with water, it was found that the loss by evaporation, in the hottest and driest weather, was two and a half times as great as the quantity supplied for consumption.

These statistics will give some idea of the enormous evaporation that goes on from the water surfaces of the globe, and to this must be added all that takes place from the land. In the case of light showers, nearly the whole of the rain is re-evaporated; and probably, on an average, half of the total rainfall on the land is thus lost sooner or later, leaving not more than half for the supply of springs and rivers. The quantity of vapor in the air is very variable. To us in England, the west and southwest winds are the dampest, coming direct from the Atlantic, and northeast winds are the driest. The cause of their extreme dryness I shall endeavor to explain presently. It is no doubt partly due to the fact that they reach us from the land surface of Europe, but partly also to another cause to which I shall have to advert later on.

The quantity of vapor in the air is usually ascertained by the hygrometer, the ordinary form of which is a pair of thermometers, one having the bulb wet, the other dry, and observing the depression of the wet bulb. The principle of this I have already explained. But the same thing may be ascertained more directly by passing a measured quantity of air through a light apparatus containing sulphuric acid, or some other substance that absorbs water vapor greedily, and weighing the whole before and afterward. The increase of the second weight gives the weight of water absorbed. By such means it has been ascertained that air at 60° can contain as much as 5½ grains of vapor in each cubic foot, and that air at 80° can contain rather less than 11 grains in the same space. The quantity that air can hold increases therefore very rapidly with the temperature.

* A lecture delivered at the Hythe School of Musketry on November 19, 1888.—*Nature*.

But it is seldom that it contains this maximum amount, especially at the higher temperatures.

In order to condense any part of this vapor, we must take away its latent heat. It is not sufficient merely to cool it till it reaches the temperature of condensation, but we have further to abstract $5\frac{1}{2}$ times as much heat as would raise the condensed water from the freezing to the boiling point. Before, however, proceeding to consider how this cooling is effected, the question arises, What is the condensing point? For obviously, since water can evaporate at all temperatures, so we should expect that it may condense at all temperatures. On what, then, does the condensing point depend?

I mentioned just now that air at the temperature of 60° can contain as much as $5\frac{1}{2}$ grains of vapor, and at 80° rather less than 11 grains in each cubic foot. Obviously, then, if air at 80° containing this maximum quantity, be cooled to 60° , it must get rid of more than 5 grains, or nearly half its vapor, and this excess must be condensed. I speak of air containing these quantities, but in point of fact it makes no appreciable difference whether air be present or not. An exhausted glass vessel of one cubic foot capacity can hold $5\frac{1}{2}$ grains of vapor at 60° and no more, and nearly 11 grains at 80° and no more; and if, when thus charged at 80° , its contents be cooled to 60° , more than 5 grains will be condensed. If, however, it contain only $5\frac{1}{2}$ grains at 80° , none will condense until the temperature falls to 60° , but any further cooling produces some condensation. Thus, then, the condensing point depends on the quantity of vapor present in the air, and is the temperature at which this quantity is the maximum possible for that temperature.

This preliminary point being explained, we may now proceed to inquire what means nature employs to condense the vapor in the air, producing at one time dew and hoar frost, at another time fog and cloud, and at another rain, hail, and snow.

Let us take the case of dew and hoar frost first, as they are comparatively simple. And in connection therewith I may relate a little incident that took place at Calcutta some years ago. A gentleman, who had not much acquaintance with physical science, was sitting one evening with a glass of iced brandy and water before him. It was in the rainy season, when the air, though warm, is very damp, and he had a large lump of ice in his tumbler. On taking it up, he noticed to his surprise that the glass was wet on the outside, and was standing in quite a little pool of water on the table. At first he thought his tumbler was cracked, but putting his finger to his tongue he found the fluid tasteless. "Very odd!" he remarked; "the water comes through the glass, but the brandy doesn't."

Now, however, with our present knowledge we may be inclined to smile at the simplicity of this remark. It so happens that up to the end of the last century very much the same explanation was popularly held to account for dew.

It was supposed to be a kind of perspiration emitted from the earth, and no satisfactory explanation of the phenomenon had been arrived at by the physical philosophers of the day. It remained for Dr. Wells to prove, by a long series of observations and experiments, which have been quoted by Sir John Herschel and Mr. John Stewart Mill as a typical instance of philosophical inquiry, that the cold surfaces of grass and shrubs condense the vapor previously held in suspension in the air, these surfaces being cooler than the air, and below its point of condensation.

And such, of course, is also the case of the glass tumbler containing ice. Any one may try the experiment for himself. To produce hoar frost, it is only necessary to cool the condensing surface below the freezing point, which may be done by crushing some ice and mixing it with salt. A tin pot is better than a glass to make this experiment.

When not only the ground, but also the air to a considerable height above it, is cooled in like manner, we have the production of fog, fog being the form in which the vapor is first condensed, and consisting of water in drops too minute to be separately visible. The formation of fog is very much aided if the air be laden with smoke. Smoke consists of extremely minute particles of unburnt coal or other fuel, and these cool faster than the air at night, and so cool the air in contact with them. Each one of them, too, condenses water on its surface, and being thus weighted, they sink and form that dense fog that Londoners know so well.

Clouds are essentially the same as fog, but formed high up in the air. But in their case, and that of rain, snow, and hail, another and different cooling agency comes into play, and this will require some preliminary explanation.

I dare say that some of you may at some time or other have charged an air gun. And if so, you will be aware that when so charged the reservoir becomes pretty warm. Now this heat is produced, not, as might be supposed, by the friction of the piston in charging, but is due to the fact that work has been done upon the air by compressing it into a very small space; in other words, work has been converted into heat. If the compressed air be allowed to escape at once, its heat is reconverted into work. It has to make room for itself by thrusting aside the atmosphere into which it escapes, and when thus expanded it is no warmer than before it was compressed. Indeed, not so warm, for it will already have parted with some of its heat to the metal chamber which contained it. And if, when compressed, it is allowed to cool down to the ordinary temperature, and then to escape, it will be cooled below that temperature, just as much as it was heated by compression. Thus, if in being compressed it had been heated 100° , say from 60° to 100° , and then allowed to cool to 60° , on escaping it will be cooled 100° below 60° , or to 40° below zero, which is the temperature at which mercury freezes. This is the principle of the cold air chambers now so extensively employed on ship-board for the transport of frozen provisions from New Zealand and Australia.

Bearing in mind, then, this fact—that air in expanding and driving aside the air into which it expands is always cooled—let us see how this applies to the case before us, the production of cloud and rain.

The volume of a given weight of air—in other words, the space it occupies—depends on the pressure to which it is subject; the less this pressure, the greater its volume. If we suppose the atmosphere divided into a number of layers superimposed on each other, the bottom layer is clearly subject to the pressure of all

those that rest on it. This is equal to about $14\frac{1}{2}$ pounds on every square inch of surface. Another layer, say 1,000 feet above the ground, will clearly be under a less pressure, since 1,000 feet of air are below it; and this 1,000 feet of air weighs slightly less than half a pound for every square inch of horizontal surface. At 2,000 feet the pressure will be less by nearly one pound per square inch, and so on. If, then, any mass of air begins to ascend through the atmosphere, it will be continually subject to less and less pressure as it ascends; and, therefore, as we have already seen, it expands, and becomes cooler by expansion. Cooling from this cause is termed dynamic cooling. Its rate may be accurately computed from the work it has to do in expanding.

It amounts to 1° for every 188 feet of ascent if the air be dry or free from vapor, and if, as is always the case, it contains some vapor, the height will not be very much greater so long as there is no condensation. But so soon as this point is passed, and the vapor begins to condense as cloud, the latent heat set free retards the cooling, and the height through which this cloud-laden air must ascend to cool 1° is considerably greater, and varies with the temperature and pressure. When the barometer stands at 30 inches, and at the temperature of freezing, the air must rise 277 feet to lose 1° , and if the temperature is 60° , nearly 400 feet of descent, owing to the re-evaporation of the fog or cloud and the absorption of latent heat.

(To be continued.)

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